TOTAL MAXIMUM DAILY LOADS FOR METALS
LOS ANGELES RIVER AND TRIBUTARIES

U.S. Environmental Protection Agency
Region 9

California Regional Water Quality Control Board
Los Angeles Region

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

µg/L	Micrograms per liter
ACF	Acute Conversion Factor
AU	Analytical Unit
BLM	Biotic Ligand Model
BMPs	Best Management Practices
Caltrans	California Department of Transportation
CCC	Criteria Continuous Concentration
CCF	Chronic Conversion Factor
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CMC	Criteria Maximum Concentration
CTR	California Toxics Rule
CWA	Clean Water Act
EFDC1D	Environmental Fluid Dynamics Code 1-D
EMC	Event Mean Concentration
EPA	Environmental Protection Agency
FHWA	Federal Highway Administration
GWR	Ground Water Recharge
HSPF	Hydrologic Simulation Program-Fortran
IPWP	Integrated Plan for the Wastewater Program
IRP	Integrated Resources Plan
LACDPW	Los Angeles County Department of Public Works
LARWQCB	Los Angeles Regional Water Quality Control Board
LSPC	Loading Simulation Program in C++
MCLs	Maximum Contaminant Levels
MGD	Million Gallons Per Day
MS4	Municipal Separate Storm Sewer System
MUN	Municipal Supply
NCDC	National Climatic Data Center
NHD	National Hydrography Dataset
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Wastewater Treatment Works
SCAG	Southern California Association of Governments
SCCWRP	Southern California Coastal Water Research Project
SIP	State Implementation Plan
TMDL	Total Maximum Daily Loads
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VOCs	Volatile Organic Compounds
WASP5	Water Quality Analysis Simulation Program
WDRs	Waste Discharge Requirements
WER	Water Effect Ratio

WLA	Waste Load Allocation
WMP	Watershed Monitoring Program
WQBELs	Water Quality Based Effluent Limits
WQOs	Water Quality Objectives
WRPs	Water Reclamation Plants

1. INTRODUCTION

Segments of the Los Angeles River and its tributaries (Figure 1) exceed water quality objectives for a variety of metals. These segments (*i.e.*, reaches) of the Los Angeles River and tributaries are included on the California 303(d) list of impaired waterbodies (LARWQCB, 1998a and 2002). The Clean Water Act requires a Total Maximum Daily Load (TMDL) be developed to restore the impaired waterbodies, including the Los Angeles River, to their full beneficial uses. Table 1-1 summarizes the stream reaches and tributaries of the Los Angeles River watershed included on the California 303(d) list for metals.

Table 1-1. Segments of the Los Angeles River and tributaries listed as impaired for metals (LARWQCB, 1998a and 2002)

Listed Waterbody Segment	Copper	Cadmium	Lead	Zinc	Aluminum	Selenium
Aliso Canyon Wash						X
Dry Canyon Creek						N
McCoy Canyon Creek						N
Monrovia Canyon Creek			X			
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)			X			
Tujunga Wash (from Hansen Dam to Los Angeles River)	X					
Burbank Western Channel		X				
Los Angeles River Reach 2 (from Figueroa St. to Carson St.)			X			
Rio Hondo Reach 1 (from the Santa Ana Fwy to Los Angeles River)	X		X	X		
Compton Creek	X		X			
Los Angeles River Reach 1 (from Carson St. to estuary)	N	N	X	N	N	

X: listed as impaired in 1998 303(d) list and part of analytical unit 13. N: New waterbody listing based on 2002 303(d) list, not part of analytical unit 13

TMDLs are developed for reaches on the 1998 and 2002 303(d) lists and for reaches where recent data indicates impairments. Metals allocations are developed for upstream reaches and tributaries that drain to impaired reaches. These TMDLs comply with 40 CFR 130.2 and 130.7, Section 303(d) of the Clean Water Act and U.S. Environmental Protection Agency (EPA) guidance for developing TMDLs in California (USEPA, 2000a). This document summarizes the information used by the EPA and the California Regional Water Quality Control Board, Los Angeles Region (Regional Board) to develop TMDLs and allocations for metals. The California Water Code (Porter-Cologne Water Quality Control Act) requires that an implementation plan be developed to achieve water quality objectives. Figure 1 shows the waterbodies addressed in this TMDL.

1.1 Regulatory Background

Section 303(d) of the Clean Water Act (CWA) requires that each State "shall identify those waters within its boundaries for which the effluent limitations are not stringent enough to implement any water quality objective applicable to such waters." The CWA also requires states to establish a priority ranking for waters on the 303(d) list of impaired waters and to establish TMDLs for such waters.

The elements of a TMDL are described in 40 CFR 130.2 and 130.7 and Section 303(d) of the CWA, as well as in the U.S. Environmental Protection Agency guidance (USEPA, 2000a). A TMDL is defined as the "sum of the individual waste load allocations for point sources and load allocations for nonpoint sources and natural background" (40 CFR 130.2) such that the capacity of the waterbody to assimilate pollutant loads (the loading capacity) is not exceeded. A TMDL is also required to account for seasonal variations and include a margin of safety to address uncertainty in the analysis (USEPA, 2000a).

States must develop water quality management plans to implement the TMDL (40 CFR 130.6). The EPA has oversight authority for the 303(d) program and is required to review and either approve or disapprove the TMDLs submitted by states. In California, the State Water Resources Control Board (State Board) and the nine Regional Water Quality Control Boards are responsible for preparing lists of impaired waterbodies under the 303(d) program and for preparing TMDLs, both subject to EPA approval. If EPA disapproves a TMDL submitted by a state, EPA is required to establish a TMDL for that waterbody. The Regional Boards also hold regulatory authority for many of the instruments used to implement the TMDLs, such as the National Pollutant Discharge Elimination System (NPDES) permits and state-specified Waste Discharge Requirements (WDRs).

The Regional Board identified over 700 waterbody-pollutant combinations in the Los Angeles Region requiring TMDLs (LARWCQB, 1996, 1998a). These are referred to as "listed" or "303(d) listed" waterbodies or waterbody segments. A schedule for development of TMDLs in the Los Angeles Region was established in a consent decree (Consent Decree) between USEPA and several environmental groups approved on March 22, 1999 (Heal the Bay Inc., et al. v. Browner, C 98-4825 SBA). For the purpose of scheduling TMDL development, the decree combined the more than 700 waterbody-pollutant combinations into 92 TMDL analytical units. The 303(d) list was updated in 2002. These updates and changes are not reflected in the Consent Decree.

This TMDL addresses Analytical Unit (AU) #13 of the Consent Decree which consists of segments of the Los Angeles River and tributaries with impairments by metals (cadmium, copper, lead, selenium, and zinc). Table 1-1 identifies the listed waterbodies by the metals causing impairments. The Consent Decree schedule requires that this TMDL be completed by March 22, 2004. If the Regional Board fails to develop the TMDL, EPA must promulgate the TMDL by March 22, 2005. EPA and the consent decree plaintiffs recently agreed to extend the completion deadline to December 22, 2005, in order to enable the State to complete its adoption process and EPA to approve the State-adopted TMDLs for this water body. The 2002 303(d) listings approved in 2003 are not required to be addressed per the Consent Decree; however, where appropriate, this TMDL addresses those listings as well.

This report presents the TMDLs for metals and summarizes the analyses performed by EPA and the Regional Board to develop this TMDL. This report does not address the metals TMDLs required for four lakes in the Los Angeles River watershed as part of Analytical Unit #20. These four lakes (Lake Calabasas, Echo Lake, Lincoln Park Lake and Peck Road Lake) are not hydrologically connected to the Los Angeles River or the listed tributaries. The TMDLs for these lakes are not scheduled in the Consent Decree but must be established by March 22, 2012. This report does not address metals impairments for Los Angeles Harbor or San Pedro Bay required under Analytical Units #75 and #78, respectively. These TMDLs have not been specifically scheduled in the Consent Decree, but are required to be completed by 2012.

The proposed TMDL for metals will be adopted as an amendment to the Regional Board's *Water Quality Control Plan for the Los Angeles Region* (Basin Plan). The Secretary of Resources has certified the basin planning process as exempt from certain requirements of the California Environmental Quality Act (CEQA), including preparation of an initial study, negative declaration, and environmental impact report (California Code of Regulations, Title 14, Section 15251(g)). The Basin Plan amendment and supporting documents, including this staff report and the CEQA checklist are considered substitute documents to an initial study, negative declaration, or environmental impact report. Regional Board staff held a CEQA Scoping meeting on April 23, 2004 in order to receive stakeholder input on the scope and content of the TMDL documents. Regional Board Staff presented an overview of reasonably foreseeable means of compliance with the TMDL in order to facilitate the scoping discussion and to identify possible impacts of the TMDL implementation.

1.2 Environmental Setting

The Los Angeles River flows for 55 miles from the Santa Monica Mountains at the western end of the San Fernando Valley to Queensway Bay located between the Port of Long Beach and the City of Long Beach. It drains a watershed with an area of 834 square miles. Approximately 44% of the watershed area can be classified as forest or open space. These areas are primarily within the headwaters of the Los Angeles River in the Santa Monica, Santa Susana, and San Gabriel Mountains, including the Angeles National Forest, which comprises approximately 200 square miles of the watershed. Approximately 36% of the land use can be categorized as residential, 10% as industrial, 8% as commercial, and 3% as agriculture, water and other. The more urban uses are found in the lower portions of the watershed.

The natural hydrology of the Los Angeles River Watershed has been altered by channelization and the construction of dams and flood control reservoirs. The Los Angeles River and many of its tributaries are lined with concrete for most or all of their lengths. Soft-bottomed segments of the Los Angeles River occur where groundwater upwelling prevented armoring of the river bottom. These areas typically support riparian habitat.

The mainstem of the Los Angeles River begins by definition at the confluence of Arroyo Calabasas (which drains the northeastern portion of the Santa Monica Mountains) and Bell Creek (which drains the Simi Hills). McCoy Canyon Creek and Dry Canyon Creek (listed for selenium) are tributary to Arroyo Calabasas. The river flows east from its origin along the southern edge of the San Fernando Valley. The Los Angeles River also receives flow from Browns Canyon, Aliso Canyon Wash (listed for selenium) and Bull Creek which drain the Santa Susana Mountains. The lower portions of Arroyo Calabasas and Bell Creek are channelized. Browns Canyon, Aliso Creek and Bull Creek are completely channelized.

Reach 5 of the Los Angeles River runs through Sepulveda Basin. There are no listings for metals in Reach 5 of the Los Angeles River. The Sepulveda Basin is a 2,150-acre open space designed to collect floodwaters during major storms. Because the area is periodically inundated, it remains in natural or semi-natural conditions and supports a variety of low-intensity land uses. The D.C. Tillman Wastewater Reclamation Plant (WRP), a publicly owned wastewater treatment works (POTW) operated by the City of Los Angeles, discharges to Reach 5 indirectly via two lakes in the Sepulveda Basin that are used for recreation and wildlife habitat. The POTW has a treatment design capacity of 80 million gallons per day (mgd) and contributes a substantial flow to the Los Angeles River. Most of the POTW flow discharges directly to Reach 4 of the Los Angeles River just below the Sepulveda Dam.

Reach 4 of the Los Angeles River runs from Sepulveda Dam to Riverside Drive. This section of the river is listed for lead. Pacoima Wash and Tujunga Wash are the two main tributaries to this reach. Both tributaries drain portions of the Angeles National Forest in the San Gabriel Mountains. Pacoima Wash is channelized below Lopez Dam to the Los Angeles River. Tujunga Wash (listed for copper) is channelized for the 10-mile reach below Hansen Dam. Some of the discharge from Hansen Dam is diverted to spreading grounds for groundwater recharge, but most of the flow enters the channelized portion of the stream.

Reach 3 of the Los Angeles River, which runs from Riverside Drive to Figueroa Street, is not listed for metals. The two major tributaries to this reach are the Burbank Western Channel and Verdugo which drain the Verdugo Mountains. Both tributaries are channelized. The Western Channel receives flow from the Burbank Water Reclamation Plant, a POTW with a design capacity of 9 mgd. The Burbank Western Channel is listed for cadmium.

At the eastern end of the San Fernando Valley, the Los Angeles River turns south around the Hollywood Hills and flows through Griffith Park and Elysian Park in an area known as the Glendale Narrows. This area is fed by natural springs during periods of high groundwater. The river is channelized and the sides are lined with concrete. The river bottom in this area is unlined because the water table is high and groundwater routinely discharges into the channel, in varying volumes depending on the height of the water table. The Los Angeles-Glendale Water Reclamation Plant, operated by the City of Los Angeles, has a design capacity of 20 mgd and discharges to the Los Angeles River in the Glendale Narrows.

Reach 2 of the Los Angeles River, which runs from Figueroa Street to Carson Street, is listed for lead. The first major tributary below the Glendale Narrows is the Arroyo Seco, which drains areas of Pasadena and portions of the Angeles National Forest in the San Gabriel Mountains. In wet periods, rising stream flows in the Los Angeles River above Arroyo Seco have been related to the increase of rising groundwater. There is up to 3,000 acre-feet of recharge from the Pollock

Well Field area that adds to the rising groundwater. For the 2000-01 water year, the total rising groundwater flow was estimated at 3,900 acre-feet (ULARA Watermaster Report, 2000-2001 Water Year, May 2002).

The next major tributary is the Rio Hondo. The Rio Hondo and its tributaries drain a large area in the eastern portion of the watershed. Flow in the Rio Hondo is managed by the Los Angeles County Department of Public Works (LACDPW). At Whittier Narrows, flow from the Rio Hondo can be diverted to the Rio Hondo Spreading Grounds. During dry weather, virtually all the water in the Rio Hondo goes to groundwater recharge, so little or no flow exits the spreading grounds to Reach 1 of the Rio Hondo. During storm events, Rio Hondo flow that is not used for spreading, reaches the Los Angeles River. This flow is comprised of both storm water and treated wastewater effluent from the Whittier Narrows Water Reclamation Plant. Reach 1 of the Rio Hondo is listed for copper, lead, and zinc. Monrovia Canyon Creek is also listed for lead. This creek, located in the foothills of the San Gabriel Mountains in the National Forest, is a tributary to Sawpit Creek which runs into Peck Lake and ultimately to Rio Hondo Reach 2 above the spreading grounds.

Reach 1 of the Los Angeles River, which runs from Carson Street to the estuary, was listed for lead in 1998. Listings for aluminum, copper, cadmium, and zinc were added in 2002 based on exceedances of standards in storm water samples. Compton Creek (listed for copper and cadmium) is the last large tributary to the system before the river enters the estuary. The creek is channelized for most of its 8.5 mile length.

The tidal portion of the Los Angeles River begins at Willow Street and runs approximately three miles before joining with Queensway Bay located between the Port of Long Beach and the City of Long Beach. In this reach, the channel has a soft bottom with concrete-lined sides. Sandbars accumulate in the portion of the river where tidal influence is limited.

During dry weather, most of the flow in the Los Angeles River is comprised of wastewater effluent from the Tillman, Los Angeles-Glendale and Burbank treatment plants. In the dry season, POTW mean monthly discharges totaled 70% to 100% of the monthly average flow in the river. The median daily flow in the Los Angeles River is 94 mgd (145 cfs), based on flows measured at the LACDPW Wardlow station over a 12-year period (October 1998 through December 2000). During wet weather, the river's flow may increase by two to three orders of magnitude due to storm water runoff. Average daily flows greater than 322 mgd (501 cfs) were observed 10% of the time. In months with rain events, POTW monthly average discharges together were less than 20% of the monthly average flow in the river.

The high flows in the wet season originate as storm runoff both from the areas of undeveloped open space in the mountains of the tributaries' headwaters and from the urban land uses in the flat low-lying areas of the watershed. Rainfall in the headwaters flows rapidly because the watershed and stream channels for the most part are steep. In the urban areas, about 5,000 miles of storm drains in the watershed convey storm water flows and urban runoff to the Los Angeles River. The watershed produces storm flow in the river with a sharply peaked hydrograph where flow increases quite rapidly after the beginning of rain events in the watershed, and declines rapidly after rainfall ceases. The Los Angeles River metals TMDL therefore accounts for differences in both flow and the relative contributions of pollutant sources between wet and dry periods.

1.3 Elements of a TMDL

Guidance from USEPA (2002a) identifies seven elements of a TMDL. Sections 2 through 8 of this document are organized such that each section describes one of the elements, with the analysis and findings of this TMDL for that element. The elements are:

- Section 2: Problem Identification. This section reviews the metals data used to add the waterbody to the 303(d) list, and summarizes existing conditions using that evidence along with any new information acquired since the listing. This element identifies those reaches that fail to support all designated beneficial uses; the beneficial uses that are not supported for each reach; the water quality objectives (WQOs) designed to protect those beneficial uses; and, in summary, the evidence supporting the decision to list each reach, such as the number and severity of exceedances observed.

- Section 3: Numeric Targets. For this TMDL, the numeric targets are based upon the WQOs described in the California Toxics Rule (CTR).

- Section 4: Source Assessment. This section develops the estimate of current metals loadings from point sources and non-point sources into the Los Angeles River.

- Section 5: Linkage Analysis. This analysis shows how the sources of metals compounds into the waterbody are linked to the observed conditions in the impaired waterbody. The linkage analysis addresses the critical conditions of stream flow, loading, and water quality parameters.

- Section 6: TMDL and Pollutant Allocation. This section identifies the total allowable loads that can be discharged without causing water quality exceedances. Each pollutant source is allocated a quantitative load of metals that it can discharge without exceeding the numeric targets. Allocations are designed such that the waterbody will not exceed numeric targets for any of the compounds or related effects. Allocations are based on critical conditions, so that the allocated pollutant loads may be expected to attain water quality standards at all times.

- Section 7: Implementation. This section describes the plans, regulatory tools, or other mechanisms by which the waste load allocations and load allocations are to be achieved.

- Section 8: Monitoring. This TMDL includes a requirement for monitoring the waterbody to ensure that the water quality standards are attained. If the monitoring results demonstrate the TMDL has not succeeded in removing the impairments, then revised allocations will be developed. It also describes special studies to address uncertainties in assumptions made in the development of this TMDL and the process by which new information may be used to refine the TMDL. While the TMDL identifies the goals for a monitoring program, the Executive Officer will issue subsequent orders to identify the specific requirements and the specific entities that will develop and implement a monitoring program and submit technical reports.

2. PROBLEM IDENTIFICATION

This section provides an overview of water quality standards for the Los Angeles River and reviews water quality data used in the 1998 water quality assessment, the 2002 303(d) listing and any additional data which may be pertinent to the assessment of condition.

2.1 Water Quality Standards

California state water quality standards consist of the following elements: 1) beneficial uses; 2) narrative and/or numeric water quality objectives; and 3) an antidegradation policy. In California, beneficial uses are defined by the Regional Water Quality Control Boards (Regional Boards) in the Water Quality Control Plans (Basin Plans). Numeric and narrative objectives are specified in each region's Basin Plan. These are designed to be protective of the beneficial uses in each waterbody in the region or State Water Quality Control Plans.

For certain toxic pollutants, the EPA has established numeric criteria that serve as water quality standards for California's inland surface waters. (40 CFR 131.38.) EPA established the numeric criteria in the California Toxics Rule (CTR) at levels that reflect when toxic pollutants are present in toxic amounts. In other words, if a pollutant is present in a surface waterbody at a level higher than a CTR criterion, then the surface waterbody is toxic. The federal water quality criteria established by the CTR are equivalent to state water quality objectives and they serve the same purpose. For the Los Angeles region, numeric objectives for toxics can be found in the CTR (40 CFR 131.38).

2.1.1. Beneficial Uses. The Basin Plan for the Los Angeles Region (1994) defines 14 beneficial uses for the Los Angeles River. These uses are summarized in Table 2-1. The Basin Plan (1994) identifies beneficial uses as existing (E), potential (P), or intermittent (I) uses. Those uses that are most likely to be impacted by metals loadings to the Los Angeles River are the beneficial uses associated with aquatic life (i.e., wildlife habitat, warm freshwater water habitat, rare threatened or endangered species, wetland habitat, and marine habitat) and water supply (i.e., groundwater recharge).

Existing use designations for warm freshwater, wildlife, wetland, and rare, threatened or endangered species habitats (WARM, WILD, WET, and RARE) apply over much of the mainstem and Compton Creek in the lower part of the watershed. The WARM designation applies as either an intermittent or potential use to the remaining listed tributaries. The WILD designation is for the protection of fish and wildlife. This use applies to much of the mainstem of the Los Angeles River, as an intermittent use in Rio Hondo, and as potential use in the remainder of the tributaries. Water quality objectives developed for the protection of fish and wildlife are applicable to the reaches with the WARM, WILD, WET and RARE designations.

Table 2-1. Beneficial uses in listed reaches of the Los Angeles River (LARWQCB, 1994)

STREAM REACH	MUN	GWR	REC1	REC2	WILD	WARM	SHELL	RARE	MIGR	SPWN	WET	MAR	IND	PROC
Aliso Canyon Wash	P*	I	I[1]	I	E	I								
Dry Canyon Creek	P*	I	I[1]	I	E	I								
McCoy Canyon Creek	P*	I	I	I	E	I								
Monrovia Canyon Creek	I	I	I	I	E	I					E			
Los Angeles River (Reach 4)	P*	E	E	E	E	E					E		P	
Tujunga Wash	P*	I	P[1]	I	P	P								
Burbank Western Channel	P*		P[1]	I	P	P								
Los Angeles River (Reach 2)	P*	E	E[1]	E	P	E							P	
Rio Hondo (Reach 1)	P*	I	P[1]	E	I	P								
Compton Creek	P*	E	E[1]	E	E	E					E			
Los Angeles River (Reach 1)	P*	E	E[1]	E	E	E	P[1]	E	P	P		E	P	P

*Municipal designations marked with an asterisk are conditional.
E: Existing beneficial use, P: Potential beneficial use, I: Intermittent beneficial use, 1: Use restricted by LACDPW

The municipal supply (MUN) use designation applies to several tributaries to the Los Angeles River and all groundwater in the Los Angeles River watershed. Other waterbodies within Region 4 also have a conditional designation for MUN. These waterbodies are indicated with an asterisk in the Basin Plan. Conditional designations are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], Feb. 15, 2002.) The ground water recharge (GWR) use designation applies to the Los Angeles River and its tributaries as either an existing or intermittent beneficial use.

2.1.2 Water Quality Objectives (WQOs). Narrative water quality objectives are specified by the 1994 Regional Board Basin Plan. The following narrative standards are most pertinent to the metals TMDL:

> *Surface waters shall not contain concentrations of chemical constituents in amounts that adversely affect any designated beneficial use.*

Toxic substances shall not be present at levels that will bioaccumulate in aquatic life resources to levels which are harmful to aquatic life or human health.

All waters shall be maintained free of toxic substance in concentrations that are toxic to, or that produce detrimental physiological responses in human, plant, animal, or aquatic life.

The Regional Board's narrative toxicity objective reflects and implements national policy set by Congress. The Clean Water Act states that, 'It is the national policy that the discharge of toxic pollutants in toxic amounts be prohibited." (33 U.S.C. 1251(a)(3).) In 2000, EPA established numeric water quality objectives for several pollutants addressed in this TMDL in the CTR. The listed pollutants covered by CTR objectives include selenium, cadmium, copper, lead, and zinc (Table 2-2). The freshwater CTR values for cadmium, copper, lead, and zinc are based on the dissolved fraction and are hardness dependent (USEPA 2000b). The freshwater CTR standard for selenium is based on the total recoverable metals concentration.

EPA expressed the CTR criteria as concentrations. Therefore, whenever a pollutant is present in a surface waterbody at a concentration in excess of a CTR criterion, the surface waterbody is toxic. EPA did not differentiate between wet and dry weather conditions in establishing the CTR. The CTR criteria therefore apply at all times to inland surface waters. This result is reached on both legal and technical grounds. Legally, the result is compelled because the CTR establishes water quality criteria (i.e., objectives) to protect aquatic life in all of California's inland surface waters. (See, 40 CFR 131.38(a), (c)(1), and (d)(1).) There is no exception for wet weather conditions in the CTR. Moreover, aquatic life is also present in wet weather conditions. The CTR is legally necessary to protect these uses in wet weather conditions. It would be illogical and illegal to conclude that the CTR does not apply in wet weather.

From a technical perspective, it would be equally inappropriate to find a wet weather exception in the CTR. Because the CTR criteria are expressed as concentrations, the volume of water is irrelevant. The concentration-based criteria essentially account for dilution in wet-weather conditions. In high-volume, wet-weather conditions, if the concentration of a toxic pollutant in a water body exceeds the CTR criterion, the water body is toxic.

The CTR establishes short-term (acute) and long-term (chronic) aquatic life criteria for metals in both freshwater and saltwater. The acute criterion, defined in the CTR as the Criteria Maximum Concentration, equals the highest concentration of a pollutant to which aquatic life can be exposed for a short period of time without deleterious effects. The chronic criterion, defined in the CTR as the Criteria Continuous Concentration, equals the highest concentration of a pollutant to which aquatic life can be exposed for an extended period of time (4 days) without deleterious effects.

CTR freshwater aquatic life criteria for certain metals are expressed as a function of hardness because hardness and/or water quality characteristics that are usually correlated with hardness can impact the toxicity of some metals. Hardness is used as a surrogate for a number of water quality characteristics, which affect the toxicity of metals in a variety of ways. Increasing hardness generally has the effect of decreasing the toxicity of metals. Water quality criteria to protect aquatic life may be calculated at different concentrations of hardness measured in milligrams per liter (mg/L) as calcium carbonate ($CaCO_3$). The CTR lists freshwater aquatic life criteria based on a hardness value of 100 mg/L and provides hardness dependent equations to calculate the freshwater aquatic life metals criteria using site-specific hardness data.

Table 2-2. Water quality objectives established in CTR. Values in table are based on a hardness value of 100 mg/L as calcium carbonate. Metals values reported as µg/L.

Metal	Freshwater Chronic	Freshwater Acute
Cadmium (dissolved)	2.2	4.3
Copper (dissolved)	9	13
Lead (dissolved)	2.5	65
Selenium (total recoverable metals)	5	Reserved
Zinc (dissolved)	120	120

The formula for calculating the hardness-adjusted acute and chronic objectives for cadmium, copper, lead, and zinc in the CTR take the form of the following equations:

$$CMC = WER * ACF * EXP[(m_a)(\ln(hardness)+b_a] \quad \text{Equation (1)}$$
$$CCC = WER * CCF * EXP[(m_c)(\ln(hardness)+b_c] \quad \text{Equation (2)}$$

Where:

CMC = Criteria maximum concentration
CCC = Criteria continuous concentration
WER = Water Effects Ratio (assumed to be 1)
ACF = Acute conversion factor (to convert from the total recoverable metals concentration to the dissolved fraction)
CCF = Chronic conversion factor (to convert from the total recoverable metals concentration to the dissolved fraction)
m_A = slope factor for acute criteria
m_C = slope factor for chronic criteria
b_A = y intercept for acute criteria
b_C = y intercept for chronic criteria

The CTR allows for the adjustment of criteria through the use of a water-effect ratio (WER) to assure that the metals criteria are appropriate for the site-specific chemical conditions under which they are applied. A WER represents the correlation between metals that are measured and metals that are biologically available and toxic. A WER is a measure of the toxicity of a material in site water divided by the toxicity of the same material in laboratory dilution water. No site-specific WER has been developed for the Los Angeles River. Therefore, a WER default value of 1.0 is assumed.

The coefficients needed for the calculation of objectives are provided in the CTR for most metals (Table 2-3). The conversion factors for cadmium and lead are hardness-dependent. The following equations can be used to calculate the conversion factors based on site-specific hardness data:

$$\text{Cadmium ACF} = 1.136672 - [(\ln\{hardness\})(0.041838)] \quad \text{Equation (3)}$$
$$\text{Cadmium CCF} = 1.101672 - [(\ln\{hardness\})(0.041838)] \quad \text{Equation (4)}$$

$$\text{Lead ACF} = 1.46203 - [(\ln\{hardness\})(0.145712)] \quad \text{Equation (5)}$$

$$\text{Lead CCF} = 1.46203 - [(\ln\{hardness\})(0.145712)] \quad \text{Equation (6)}$$

Table 2-3. Coefficients used in formulas for calculating CTR standards.

Metal	ACF	m_A	b_A	CCF	m_C	b_C
Cadmium	0.944*	1.128	-3.6867	0.909*	0.7852	-2.715
Copper	0.960	0.9422	-1.700	0.960	0.8545	-1.702
Lead	0.791*	1.2730	-1.460	0.791*	1.2730	-4.705
Zinc	0.978	0.8473	0.884	0.986	0.8473	0.884

* The ACF and CCF for cadmium and lead are hardness dependent. Conversion factors in this table are based on a hardness of 100 mg/L as $CaCO_3$.

2.1.3 Antidegradation. State Board Resolution 68-16, 'Statement of Policy with Respect to Maintaining High Quality Water" in California, known as the "Antidegradation Policy," protects surface and ground waters from degradation. Any actions that can adversely affect water quality in all surface and ground waters must be consistent with the maximum benefit to the people of the state, must not unreasonably affect present and anticipated beneficial use of such water, and must not result in water quality less than that prescribed in water quality plans and policies. Furthermore, any actions that can adversely affect surface waters are also subject to the federal Antidegradation Policy (40 CFR 131.12). The proposed TMDL will not degrade water quality, and will in fact improve water quality as it is designed to achieve compliance with existing, numeric water quality standards.

2.2 Water Quality Data Review

This review section summarizes water quality data used to develop this TMDL. The summary includes data considered by the Regional Board and EPA in developing the 1998 and the 2002 303(d) listings for metals and additional data submitted by the City of Los Angeles, the City of Burbank and the County of Los Angeles.

The receiving water data collected by the City of Los Angeles and the City of Burbank as part of NPDES monitoring requirements for D.C. Tillman WRP, the Los Angeles-Glendale WRP, and the Burbank WRP were reviewed to evaluate dry-weather conditions. The City of Los Angeles measures metals and hardness in receiving waters from several locations upstream and downstream of its treatment plants (Figure 1) on a quarterly basis. The data from the Tillman and Glendale receiving water stations represent six locations sampled from February 1998 to November 2002. The City of Burbank samples water quality in the Burbank Western Channel on a quarterly basis. The data from the Burbank WRP represent four stations sampled from November 1998 to December, 2003. Data from these programs were compared to the hardness adjusted dissolved criteria in the CTR using the hardness value for each sample. As both agencies analyze for concentrations of total recoverable metals, the comparison of their data to the dissolved criteria provides a conservative assessment of water quality impairment. These NPDES monitoring programs provide water quality information for Reaches 3, 4 and 5 of the Los Angeles River and the Burbank Western Channel, the results of which are summarized in Tables 2-4 and 2-5.

Table 2-4. Summary of dry-weather chronic metals criteria exceedances. Values in table reflect number of samples exceeding the chronic criteria over the total number of samples (Values below detection levels counted as zero). Source: City of Los Angeles and City of Burbank WRP NPDES receiving water monitoring.

Metals by Reach	LA River Reach 5	LA River Reach 4	LA River Reach 3	Burbank Western Channel
Cadmium	0/16	0/36	0/54	1/96
Copper	1/17	18/34	6/51	41/96
Lead	2/17	12/34	6/48	2/96
Zinc	0/17	0/34	0/51	1/96

Table 2-5. Summary of dry-weather acute metals criteria exceedances. Values in table reflect number of samples exceeding the acute criteria over the total number of samples (Values below detection levels counted as zero). Source: City of Los Angeles and City of Burbank WRP NPDES receiving water monitoring.

Metals by Reach	LA River Reach 5	LA River Reach 4	LA River Reach 3	Burbank Western Channel
Cadmium	0/16	0/34	0/42	0/96
Copper	0/18	4/36	0/51	10/96
Lead	0/17	0/34	0/48	0/96
Zinc	0/17	0/34	0/51	1/96

In January 2002, the City of Los Angeles began their Watershed Monitoring Program (WMP) which involves the monthly collection of water quality data at eight stations along the Los Angeles River (Figure 2). In this program, water quality samples are analyzed for both total recoverable and dissolved metals at eight stations along the entire length of the River. The data that were assessed were collected through May 2003, which included 17 samples collected at each station. These data provide information on spatial variability in water quality in all six reaches of the Los Angeles River (Figures 3a-3d) and can be used in conjunction with median hardness data (Table 3-1) to assess compliance with chronic CTR criteria. As with the POTW receiving water data, concentrations of total recoverable metals are compared to the dissolved criteria (adjusted using median hardness values) to provide a conservative assessment of water quality impairment. The results of this comparison are summarized in Table 2-6.

Table 2-6. Summary of dry weather chronic metals criteria exceedances. Values in table reflect number ofsamples exceeding the criteria over the total number of samples. Median hardness values for each reach (Table 3-1) were used to assess compliance with CTR criteria. Source: City of Los Angeles WMP.

Metals by Reach	LA River Reach 5	LA River Reach 4	LA River Reach 3	LA River Reach 2	LA River Reach 1
Hardness (mg/L as $CaCO_3$)	400	246	278	268	282
Cadmium	0/17	0/17	0/34	0/34	0/17
Copper	2/17	4/17	4/34	5/34	2/17
Lead	0/17	6/17	6/34	5/34	3/17
Zinc	0/17	0/17	0/34	0/34	0/17

To assess wet-weather impairments, storm water data collected by LACDPW as part of the NPDES municipal storm water permit monitoring requirements were evaluated. The LACDPW has been sampling approximately five storms per year at the Wardlow gage station since 1996. LACDPW samples hardness and metals (both dissolved and total recoverable metals) from composite storm water samples. The results of these data are summarized in Table 2-7.

Table 2-7. Summary of wet-weather acute and chronic metals criteria exceedances. Values in table reflect number of samples exceeding the criteria over the total number of samples (Values below detection levels counted as zero). Source: NPDES MS4 Monitoring at LACDPW Wardlow station between 1996 and 2002.

Metal	Number >Detection Level	Number > Chronic Criteria	Number > Acute Criteria
Cadmium (dissolved)	3/42	3/42	3/42
Copper (dissolved)	32/42	19/42	13/42
Lead (dissolved)	11/42	11/42	4/42
Selenium (total recoverable)	1/42	NA	0/42
Zinc (dissolved)	18/42	6/42	6/42

2.2.1. Summary of Results

Cadmium – The Burbank Western Channel is on the 1998 303(d) list for cadmium. In the 2002 303(d) list, a cadmium listing was added for Reach 1 of the Los Angeles River based on storm water data. Cadmium was detected in only 1 of 96 samples in any of the NPDES receiving water samples from Burbank Western Channel (Table 2-4). For a large number of samples, the reported detection limits were greater than the chronic criteria. However, the most recent data have detection limits that are below the chronic criteria and contain no exceedances. Cadmium was detected in 3 out of 42 storm water samples collected at Los Angeles River Reach 1 (Table 2-6). All three samples exceeded both the chronic and acute criteria. There were no exceedances of cadmium in Reaches 3, 4, or 5 of Los Angeles River based on data collected by the City of Los Angeles.

In summary, there is no evidence that cadmium is being exceeded in Burbank Western Channel or any other reach during dry weather. There are occasional exceedances of the cadmium standard in storm water samples. A wet-weather TMDL is required for cadmium in Reach 1. Wet-weather allocations will be applied to all upstream reaches because discharges of cadmium in upstream reaches may cause or contribute to an exceedance of water quality standards in Reach 1.

Copper – The 1998 303(d) listings for copper are in Tujunga Wash, Rio Hondo (Reach 1), and Compton Creek. In the 2002 303(d) list, a copper listing was added for Reach 1 of the Los Angeles River based on storm water data. Copper was detected in 32 out of 42 storm water samples - 19 samples exceeded the chronic criteria and 13 samples exceeded the acute criteria. A review of the City's WMP data indicates a dry-weather impairment in Reach 1 as well. The City's WMP data indicates dry-weather impairments in Reaches 1, 2, 3, 4, and 5 of the river. The data from the POTWs (Tables 2-4 and 2-5) indicate that there are dry-weather exceedances of both the chronic and acute criteria in the Los Angeles River (Reaches 3, 4 and 5) and in the Burbank Western Channel.

In summary, TMDLs are required for Tujunga, Rio Hondo, Compton, and LA Reach 1 to address the 1998 and 2002 303(d) listings. Data also indicate the need to develop TMDLs to address impairments in Reaches 2, 3, 4 and 5 of the LA River and the Burbank Western Channel.

Lead – The lead listings are from the 1998 303(d) list and are for Monrovia Canyon Creek, Rio Hondo (Reach 1), Compton Creek, and the Los Angeles River (Reaches 1, 2 and 4). There are no new data for Monrovia Canyon, Rio Hondo or Compton Creek.

A review of the dry-weather data for the Los Angeles River indicates occasional exceedances of the chronic standard in Los Angeles River (Reaches 3, 4, and 5) and Burbank Western Channel (Tables 2-4 and 2-6). The reported detection limits for lead in many of the samples from the Burbank Western Channel were higher than the chronic standard, complicating the assessment for 38 out of 96 of the samples. High detection levels were not an issue in comparing reported data with the acute standard (Table 2-5). There were no exceedances of the acute standard in samples from the Burbank Western Channel or Reaches 3, 4 or 5 of the Los Angeles River. There were exceedances of both the acute and chronic standard in Reach 1 of the Los Angeles River during storms (Table 2-6). Of the 11 samples with lead concentrations greater than the detection limit, 11 samples exceeded the chronic criteria and 4 samples exceeded the acute criteria.

In summary, TMDLs are required for Monrovia Canyon Creek, Rio Hondo (Reach 1), Compton Creek, and LA River Reaches 1, 2 and 4 to address the 1998 303(d) listings. Data also indicate the need develop TMDLs to address impairments in Reaches 3 and 5 of the LA River.

Zinc – The Rio Hondo is listed for zinc on the 1998 303(d) list. There are no new data for the Rio Hondo. In 2002, a listing for dissolved zinc was added for Reach 1 of the Los Angeles River, based on the LACDPW storm water data. There do appear to be some exceedances of the zinc standard during storms (Table 2-6). Of the 18 samples with zinc concentrations greater than the detection limit, 6 samples exceeded the chronic and acute criteria. There do not appear to be any exceedances of the acute or chronic zinc criteria in Reaches 3, 4 and 5 of the Los Angeles River (Tables 2-4 and 2-5). There was one incidence of elevated zinc in the Burbank Western Channel.

With the possible exception of Rio Hondo, there are no dry-weather impairments associated with zinc. Zinc occasionally exceeds the acute criteria in storm water samples. A dry-weather TMDL is required for zinc in the Rio Hondo (Reach 1). A wet-weather TMDL is required for LA River Reach 1. Wet-weather allocations will be applied to all upstream reaches because discharges of zinc in upstream reaches may cause or contribute to an exceedance of water quality standards in Reach 1.

Aluminum – This is not part of analytical unit #13, but aluminum was added in 2002 based on LACDPW storm water data. The total recoverable metals values for aluminum were compared to the maximum contaminant level (MCL) of 1 mg/L. The MCL was exceeded in only 2 out of 26 storm water samples collected since the year 2000. Although the MCL has been incorporated into the Basin Plan to protect the MUN beneficial use, conditional designations are not recognized under federal law and are not water quality standards requiring TMDL development at this time. (See Letter from Alexis Strauss [USEPA] to Celeste Cantú [State Board], Feb. 15, 2002.)

Selenium – Aliso Canyon Wash was listed for selenium on the 1998 303(d) list. In 2002, two more tributaries (McCoy Canyon Creek and Dry Canyon Creek) were listed for selenium. We analyzed selenium data collected by the City of Calabasas on a monthly basis between July 2000 and July 2002 as part of a 319h grant provided by the Regional Board. At the two stations in

McCoy Canyon Creek, the CTR value of 5 µg/l was exceeded in 27 out of 29 samples. The maximum measured value was 44 µg/l. The selenium values were lower at the two Dry Canyon Creek stations. At these stations, values greater than 5 µg/l were observed in 12 out of 54 samples. We also assessed selenium data collected by the City of Los Angeles at eight stations along the Los Angeles River in 2002 and 2003 as part of their Watershed Monitoring Program. Selenium values greater than 5 µg/l were observed in 14 out of 136 samples. All of these were from the Los Angeles River Reach 6 (where 14 out of 17 exceeded the CTR value). None of the other samples from any of the downstream stations on the Los Angeles River exceeded the CTR value. The selenium issue seems to be confined to the upper reaches of the watershed and tributaries draining to Reach 6. Because there is little industrial activity in this area, we believe that the selenium in the waterbody originates from natural sources such as marine shales (EDAW, 2003). A concentration-based load allocation is therefore being assigned to Reach 6 and its tributaries. Separate studies are underway to evaluate whether selenium levels represent a natural condition for this watershed.

Conclusions. Our review of the data indicates that there are occasional exceedances of copper and lead during dry-weather conditions in reaches1, 2, 3, 4, and 5 and some tributaries. A single exceedance for cadmium was identified in the Burbank Western Channel during dry weather. There are also occasional exceedances of CTR criteria in storm water for copper, lead and to a lesser extent for zinc and cadmium. High selenium values were only observed at stations located in the upper portion of the watershed, which we believe are associated with natural sources. Finally, we find that a TMDL for aluminum is not warranted to protect a conditional use. Table 2-8 presents a summary of the data review used to determine which reaches and tributaries require TMDLs.

Table 2-8. Summary of recent data review. Values reflect percent excedances of CTR criteria by NPDES receiving water data unless otherwise noted.

Listed Waterbody Segment (Dry)	Data Source	Cadmium	Copper	Lead	Zinc	Aluminum	Selenium
Aliso Canyon Wash							No new data
Dry Canyon Creek	319h grant						93%
McCoy Canyon Creek	319h grant						22%
Los Angeles River Reach 6	319h grant						10%
Los Angeles River Reach 5	NPDES, WMP	0%	6%, 12%[1]	12%	0%		
Los Angeles River Reach 4 (Sepulveda Dam to Riverside Dr.)	NPDES, WMP	0%	53%, 24%[1]	35%	0%		
Tujunga Wash (from Hansen Dam to Los Angeles River)		No new data					
Burbank Western Channel	NPDES	1%	4%	2%			
Los Angeles River Reach 3	NPDES, WMP	0%	12%	13%, 18%[1]			
Los Angeles River Reach 2	WMP	0%	15%[1]	No new			

Listed Waterbody Segment (Dry)	Data Source	Cadmium	Copper	Lead	Zinc	Aluminum	Selenium
(from Figueroa St. to Carson St.)				data			
Monrovia Canyon Creek				No new data			
Rio Hondo Reach 1 (from the Santa Ana Fwy to Los Angeles River)			No new data	No new data	No new data		
Compton Creek			No new data	No new data			
Los Angeles River Reach 1 (from Carson St. to estuary)	WMP	0%	12%[1]	18%[1]	0%		
Listed Waterbody Segment (Wet)		**Cadmium**	**Copper**	**Lead**	**Zinc**	**Aluminum**	**Selenium**
Los Angeles River Reach 1 (from Carson St. to estuary)	Storm Water	7%	31%	10%	14%	8%	0%

1 – WMP samples compared to dissolved CTR criteria using median hardness values.

Dry-weather TMDLs will be developed for the following pollutant waterbody combinations:

- Copper for the Los Angeles River Reaches 1, 2, 3, 4, and 5, Burbank Western Channel, Rio Hondo Reach 1, Compton Creek and Tujunga Wash. Allocations will be developed for upstream reaches and tributaries to meet TMDLs in downstream reaches. No copper allocation will be assigned to Monrovia Canyon creek because its flow does not reach the mainstem of the river during dry weather.
- Lead for the Los Angeles River Reaches 1, 2, 3, 4, and 5, Burbank Western Channel, Rio Hondo Reach 1, Compton Creek, and Monrovia Canyon Creek. Allocations will be developed for upstream reaches and tributaries to meet TMDLs in downstream reaches.
- Zinc for Rio Hondo Reach 1.
- Selenium for Reach 6, Aliso Creek, Dry Canyon Creek and McCoy Canyon Creek.

Wet-weather TMDLs will be developed for cadmium, copper, lead and zinc for the Los Angeles River Reach 1. Allocations will be developed for upstream reaches and tributaries that drain to the river in order to meet the TMDL for Reach 1. Discharges to these upstream reaches cause or contribute to exceedances of water quality standards in Reach1, and therefore, contribute to the impairment in Reach. Applying allocations to upstream reaches will also address impairments in Reach 2, Compton Creek and Tujunga Wash.

3. NUMERIC TARGETS

Numeric targets for the TMDL have been calculated based on the numeric standards in the CTR. The TMDL targets are expressed in terms of total recoverable to address the potential for transformation between the total recoverable and the dissolved metals fraction.

Separate targets are developed for dry and wet weather because hardness values and flow conditions in the Los Angeles River and tributaries vary between dry and wet weather. In this TMDL, dry-weather targets are based on the most limiting of the chronic or acute CTR criteria. For copper and lead, these are the chronic criteria. For zinc, this is the acute criterion. Wet-weather targets are developed for storm conditions based on acute criteria because it would be inappropriate to apply criteria based on long-term exposure (4-days) to storms which are generally short-term and episodic in nature. Another reason for developing distinct targets for dry and wet-weather conditions is to account for differences in hardness or fractionation between dissolved and total recoverable metals, which may affect the numeric target. The wet-weather storm condition is operationally defined when the maximum daily flow is equal to or greater than 500 cfs at the LA River Wardlow gage station. The 500 cfs value represents the 90th percentile of average daily flow at that station (1998 – 2000). The dry-weather targets apply to days when the maximum daily flow in the River is less than 500 cfs.

3.1 Dry-Weather Targets

Dry-weather numeric targets are developed for copper and lead for all reaches of the Los Angeles River and for tributaries feeding into the Los Angeles River. Dry-weather targets are also developed for lead in Monrovia Canyon Creek, Zinc in the Rio Hondo, and selenium for Los Angeles River Reach 6 and its tributaries.

The dry-weather targets for copper, lead and zinc are dependent on hardness and metals conversion factors. Hardness data for Burbank Western Channel and Reaches 3, 4, and 5 of the LA River were obtained from NPDES ambient monitoring data collected by the three POTWs in the ambient water upstream and downstream of the plants. Additional hardness data for the LA River upstream and downstream of the Tillman and Glendale plants came from a special study to develop site-specific conversion factors for copper (LWA, 2004).

Hardness values from 1988 to 1995 for Reaches 1 and 2 of the Los Angeles River and Compton Creek, Monrovia Canyon Creek and Rio Hondo Reach 1 were obtained from LACDPW. To assess the comparability of these older data, we compared the historic hardness data associated with Reaches 4 and 3 collected by LACDPW with the more recent data collected by the Tillman and Glendale POTWs in these same reaches. The results from the two data sets were extremely close (within 10 mg/), suggesting that the older data from 1988 to 1995 are comparable to the newer data and therefore appropriate for setting numeric targets. Dry-weather hardness data are presented in Table 3-1. Hardness values were not available for the Arroyo Seco, Verdugo Wash or the Tujunga Wash.

Table 3-1. Summary of dry-weather reach-specific hardness data (mg/L as CaCO3) for Los Angeles River and listed tributaries (Maximum hardness value correction is 400 mg/L).

River Reach	Number of measurements	10^{th} Percentile	Median	90^{th} Percentile
LA River Reach 5. Above Tillman (Station LAR-9)	40	608	702	832
LA River Reach 4. Below Tillman (Stations LAR-7 and LAR-8)	69	196	246	400
LA River Reach 3. Above Glendale (Station LAG-7)	17	232	282	330
LA River Reach 3. Below Glendale (Stations LAG-4, and LAG-5)	69	242	278	322
Western Channel Above Burbank (Station 1)	41	272	326	395
Western Channel Below Burbank (Stations 1.5, 2 and 5)	61	197	229	275
LA River Reach 2	83	221	268	322
Rio Hondo Reach 1	74	111	141	199
LA River Reach 1	82	219	282	340
Compton Creek	65	148	225	296
Monrovia Canyon Creek	81	182	209	239

Dry-weather targets for copper and lead are based on chronic CTR criteria. The target for the chronic criteria is based on the 50^{th} percentile of the hardness data for each reach. This is consistent with the procedures for choosing conversion factors specified by the Policy for Implementation of Toxics Objectives for Inland Surface Waters, Enclosed Bays, and Estuaries, or SIP, (SWRCB, 2000). Targets for Tujunga Wash, Verdugo Wash and Arroyo Seco are based on hardness values in the Los Angeles River Reaches 4, 3 and 2, respectively. Targets for Reach 6 and Bell Creek are based on hardness values for Reach 5.

Table 3-2. Dry-weather numeric targets for copper and lead (µg/l). Reach-specific targets based on chronic criteria and 50th percentile hardness. Conversion of dissolved to total recoverable based on default or site specific conversion factors.

Los Angeles River	Dissolved Copper	Conversion factor	Total recoverable Copper	Dissolved Lead	Conversion factor	Total recoverable Lead
LA Reach 6	29	0.96	30	11	0.59	19
LA Reach 5 above Tillman	29	0.96	30	11	0.59	19
LA Reach 4 below Tillman	19	0.74	26	6.6	0.66	10
LA Reach 3 Above LAG WRP	22	0.96	23	7.6	0.64	12
LA Reach 3 below LAG WRP	21	0.80	26	7.5	0.64	12
LA Reach 2	21	0.96	22	7.3	0.65	11
LA Reach 1	22	0.96	23	7.6	0.64	12
Tributaries	**Dissolved Copper**	**Conversion factor**	**Total recoverable Copper**	**Dissolved Lead**	**Conversion factor**	**Total recoverable Lead**
Bell	29	0.96	30	11	0.59	19
Tujunga	19	0.96	20	6.6	0.66	10
Verdugo Wash	22	0.96	23	7.6	0.64	12
Burbank (above WRP)	25	0.96	26	9.1	0.67	14
Burbank (below WRP)	18	0.96	19	6.1	0.67	9.1
Arroyo Seco	21	0.96	22	7.3	0.65	11
Compton Creek	18	0.96	19	6.0	0.67	8.9
Rio Hondo Reach 1	12	0.96	13	3.7	0.74	5.0
Monrovia Canyon Creek				5.6	0.68	8.2

The City of Los Angeles proposed site specific copper conversion factors for the areas downstream of the Tillman Plant (Reach 4) and the Glendale Plant (Reach 3) based on a study performed by Larry Walker and Associates (LWA) (LWA, 2003). For the area downstream of the Tillman Plant, the proposed conversion factors for copper were 0.57 for chronic and 0.72 for acute. For the area downstream of the Glendale Plant, the proposed conversion factors were 0.77 for chronic and 0.84 for acute. EPA and the Regional Board expressed concern about the use of these numbers given the lack of consistent relationships between total recoverable and dissolved concentrations in the dataset.

Suspecting that relationship may be affected by total suspended solids, LWA used partition coefficient modeling to account for variation due to total suspended solids. In this approach, the conversion factor is the dissolved fraction (fd), calculated using a site a specific partition coefficient (Kp) and total suspended solids. This is in accordance with EPA guidance for calculating conversion factors (USEPA, 1996) and is allowed for in the SIP (SWRCB, 2000). Using this approach LWA proposed using 0.74 as a chronic conversion factor and 0.92 as an acute conversion factor for the area downstream of Tillman. For the area downstream of Glendale, they proposed conversion factors of 0.80 for chronic and 0.89 for acute. Because the revised values were determined according to EPA and SIP guidance, they will be used in this TMDL for the areas of the River downstream of the Tillman and Glendale plants.

CTR default conversion factors for copper are used in the other reaches. CTR default values are used for lead and zinc in all reaches. Application of these default values is applied to the margin of safety for the TMDL. Evaluation of the City of Los Angeles WMP data shows that the default conversion factor over estimates the fraction of metal in the dissolved form.

The City of Los Angeles is currently pursuing an alternative method for determining site-specific copper water quality criteria based on the Biotic Ligand Model (BLM). This TMDL will include a re-opener to allow for application of site specific-water quality criteria for copper if and when these site-specific water quality criteria approved by U.S. EPA and the Regional Board.

The dry-weather target for zinc is based on acute CTR criterion, rather than chronic criterion, because the acute criterion is more protective for zinc. The target for the acute criteria is based on the 10^{th} percentile of the hardness data in the Rio Hondo (141 mg/L as $CaCO_3$). The resulting target is 131 µg/l total recoverable metals, calculated using the CTR default conversion factor of 0.978.

The dry-weather target for selenium in Reach 6 and its tributaries is 5 µg/l based on the CTR criterion for total recoverable metals. The criterion is independent of hardness or conversion factors.

3.2 Wet-Weather Targets

A wet-weather day is any day when the maxium daily flow measured at the Wardlow station is equal to or greater than 500 cfs (the 90^{th} percentile of flow). Wet-weather targets are defined for cadmium, copper, lead and zinc based on hardness a value of 80 mg/l. This represents the median hardness value from 42 storm composite samples collected by LACDPW at Wardlow Station between 1996 and 2002.

The data collected by LACDPW at Wardlow were also used in a regression analysis to evaluate the relationship between dissolved and total recoverable metals in storm water (Table 3-3). The slope of the regression reflects the ratio of the dissolved to total recoverable concentration; the r-squared value reflects the strength of the relationship.

Table 3-3. Relationship between dissolved and total recoverable metals in storm water data at Wardlow Station (1996-2002) and CTR default conversion factors.

Metal	LADPW Storm water data			Acute Coversion Factors (ACF)
	N	Slope	R^2	
Cadmium	3	-	-	0.95*
Copper	33	0.65	0.69	0.960
Lead	13	0.82	0.98	0.824*
Zinc	20	0.61	0.61	0.978

* ACF for cadmium and lead are hardness dependent and were calculated based on the hardness at Wardlow (80 mg/L as Ca CO_3)

These regressions suggest that the CTR default conversion factors generally overestimate the dissolved portion of metals in storm water. Data from literature confirm this and suggest that an even greater portion of metals is associated with particulates in wet weather. Young et al. 1980 estimated that the 90% of the cadmium, copper, lead, and zinc in storm water samples were associated with the particle phase. McPherson et al. 2004 found similar results in storm water from nearby Ballona Creek. In that study, 83% of the cadmium, 63% of the copper, and 86% of the lead were associated with the particle phase. Use of the CTR default values for wet-weather would be overly conservative. The slopes of the regressions are therefore used as conversion factors for copper, lead and zinc. The default CTR conversion factor is used for cadmium because there is insufficient local data for a site-specific value (Table 3-4).

Table 3-4. Wet-weather numeric targets.

Metal	Wet-weather Target Dissolved (µg/l)	Conversion Factor	Wet-weather Target Total Recoverable (µg/L)
Cadmium	3	0.95	3.1
Copper	11	0.65	17
Lead)	51	0.82	62
Zinc	97	0.61	159
Selenium	NA	NA	5

4. SOURCE ASSESSMENT

This section identifies the potential sources of metals to the Los Angeles River and tributaries. The toxic pollutants can enter surface waters from both point and nonpoint sources. In the context of TMDLs, pollutant sources are either point sources or nonpoint sources. Point sources include discharges for which there are defined outfalls such as wastewater treatment plants, industrial discharges and storm drain outlets. These discharges are regulated by National Pollution Discharge Elimination System (NPDES) permits (Table 4-1). Nonpoint sources, by definition, include pollutants that reach waters from a number of diffuse land uses and source activities that are not regulated through NPDES permits. An example of this would be the runoff from the National Forest and State Parks. While not subject to a NPDES permit, pollutant loadings from these areas must be addressed in the TMDL.

4.1 Point Sources.

Table 4-1. Summary of NPDES permits in Los Angeles River watershed. (SOURCE: LARWQCB).

Type of Permit	No. of Permits
Publicly Owned Treatment Works	6
Municipal Storm water	3
Industrial Storm water	1307
Construction Storm water	204
Other Major NDPES Discharges	3
Minor NPDES Discharges	15
General NPDES Discharges	
Construction Dewatering	35
Petroleum Fuel Cleanup Sites	7
VOCs Cleanup Sites	6
Hydrostatic Test Water	8
Non-Process Wastewater	9
Potable Water	25
Total	**1628**

4.1.1. Publicly Owned Treatment Works (POTWs)

There are several POTWs that either discharge, or have the potential to discharge into the Los Angeles River or listed tributaries. The three largest POTWs (Donald C. Tillman Water Reclamation Plant, Los Angeles-Glendale Water Reclamation Plant, and Burbank Water Reclamation Plant) constitute the major sources in the watershed.

- Tillman is a tertiary treatment plant with a design capacity of 80 mgd. The Tillman plant discharges approximately 53 mgd to the Los Angeles River. Most of the flow is discharged directly into the Los Angeles River (Reach 4). However, a portion of the flow goes into a recreation lake, which then drains into Bull Creek and Hayvenhurst Channel and back into the Los Angeles River (Reach 5). Another portion of the flow goes to a wildlife lake, which then drains into Haskell Channel and ultimately back into the Los Angeles River (Reach 5).

- The Los Angeles-Glendale POTW is a 20-mgd design capacity plant that discharges approximately 13 mgd directly into the Reach 3 of the Los Angeles River in the Glendale Narrows. Approximately 4 mgd of the treated wastewater is used for irrigation and industrial uses.

- Burbank has a design capacity of 9 mgd. Approximately 4 mgd is discharged directly into the Burbank Western Channel. The City of Burbank and Caltrans reclaim a portion of the effluent for irrigation (freeway landscapes, golf courses, parks etc.). Treated water from the plant is also used as cooling water for the Burbank Steam Power Plant.

- The Tapia Water Reclamation Facility (Tapia) is a 16-mgd plant that discharges into Malibu Creek. However, due to a discharge prohibition in Malibu Creek from April 15 to November 15, the permittee is allowed to discharge up to 1 mgd of wastewater to the Los Angeles River. However, this discharge is infrequent. The permitted flow from the Tapia is less than 2% of the mean flows from the major POTWs discharging to the Los Angeles River.

- The Whittier Narrows Water Reclamation Plant discharges to the Rio Hondo above the Whittier Narrows Dam, into spreading grounds where most of the effluent enters the groundwater. It has been estimated that less than 1% (0.1 mgd) of Whittier Narrows WRP effluent remains in the channel downstream of the spreading grounds.

- The Los Angeles Zoo Wastewater Facility has a 1.8 million gallon retention basin, and discharges into Reach 3 of the Los Angeles River near the Glendale Narrows only during wet weather when the retention capacity is exceeded.

4.1.2. Storm water Permits

Storm water runoff in the Los Angeles River Watershed is regulated through a number of permits. There are the municipal separate sewer system (MS4) permits issued to the Los Angeles County and the City of Long Beach. There is the statewide storm water permit issued to Caltrans. As of the writing of this TMDL, there are 1,307 permits issued under the Statewide Industrial Activities Storm Water General Permit and 204 permits issued under the Statewide Construction Activities Strom Water General Permit.

MS4 Storm Water Permits

In 1990 USEPA developed rules establishing Phase I of the NPDES storm water program, designed to prevent pollutants from being washed by storm water runoff into MS4s (or from being discharged directly into the MS4s) and then discharged from the MS4s into local waterbodies. Phase I of the program required operators of medium and large MS4s (those generally serving populations of 100,000 or more) to implement a storm water management program as a means to control polluted discharges from the MS4s. Approved storm water management programs for medium and large MS4s are required to address a variety of water quality-related issues, including roadway runoff management, municipally owned operations, and hazardous waste treatment. Large and medium MS4 operators are required to develop and implement Storm Water Management Plans that address, at a minimum, the following elements:

- Structural control maintenance
- Areas of significant development or redevelopment
- Roadway runoff management
- Flood control related to water quality issues
- Municipally owned operations such as landfills, and wastewater treatment plants
- Municipally owned hazardous waste treatment, storage, or disposal sites
- Application of pesticides, herbicides, and fertilizers
- Illicit discharge detection and elimination
- Regulation of sites classified as associated with industrial activity
- Construction site and post-construction site runoff control
- Public education and outreach

The County of Los Angeles Municipal Storm Water NPDES permit (MS4 Permit) was renewed in December 2001 (Regional Board Order No. 01-182) and is on a five-year renewal cycle. There are 85 co-permittees covered under this permit including 84 cities and the County of Los Angeles. The City of Long Beach MS4 was renewed on June 30, 1999 and is renewed on a five-year cycle.

Caltrans Storm Water Permit

Caltrans is regulated by a statewide storm water discharge permit that covers all municipal storm water activities and construction activities (State Board Order No. 99-06-DWQ). The Caltrans storm water permit authorizes storm water discharges from Caltrans properties such as the state highway system, park and ride facilities, and maintenance yards.

The storm water discharges from most of these Caltrans properties and facilities eventually end up in either a city or county storm drain. The metals loading specifically from Caltrans properties have not been determined in the Los Angeles River watershed. A conservative estimate of the percentage of the Los Angeles River watershed covered by state highways is 1.3% (approximately 6,950-acres). This reflects the area of the Department's Right-of-Way that drains to Los Angeles River (Caltrans comment letter dated 8/26/04.)

General Storm Water Permits

Federal regulations for controlling pollutants in storm water discharges were issued by the USEPA on November 16, 1990 (40 Code of Federal Regulations [CFR] Parts 122, 123, and 124). The regulations require operators of specific categories of facilities where discharges of storm water associated with industrial activity occur to obtain an NPDES permit and to implement Best Available Technology Economically Achievable (BAT) to reduce or prevent nonconventional and toxic pollutants, including metals, associated with industrial activity in storm water discharges and authorized non-storm discharges. In addition, the regulations require discharges of storm water to surface waters associated with construction activity including clearing, grading, and excavation activities (except operations that result in disturbance of less than five acres) to obtain an NPDES permit and to implement BAT to reduce or eliminate storm water pollution. On December 8, 1999, federal regulations promulgated by USEPA (40CFR Parts 122, 123, and 124) expanded the NPDES storm water program to include storm water discharges from construction sites that resulted in land disturbances equal to or greater than one acre but less then five acres.

On April 17, 1997, State Board issued a statewide general NPDES permit for Discharges of Storm Water Associated with Industrial Activities Excluding Construction Activities Permit (Order No. 97-03-DWQ). This Order regulates storm water discharges and authorized non-storm water discharges from ten specific categories of industrial facilities, including but not limited to manufacturing facilities, oil and gas mining facilities, landfills, and transportation facilities. On August 19, 1999, State Board issued a statewide general NPDES permit for Discharges of Storm Water Runoff Associated with Construction Activities (Order No. 99-08-DQW). All dischargers covered under these general NPDES storm water permits are required to develop and implement an effective Storm Water Pollution Prevention Plan (SWWPPP) and Monitoring Program. The SWPPP has two main objectives. One, to identify and evaluate sources of pollutants associated with industrial or construction activities that may affect the quality of storm water discharges. Two, to identify and implement site-specific BMPs to reduce or prevent pollutants associated with industrial activities in storm water discharges.

As of the writing of this TMDL, there are 1307 dischargers enrolled under the general industrial storm water permit in the watershed, the largest numbers occur in the cities of Los Angeles, Vernon, South Gate, Long Beach, Compton, and Commerce. Metal plating, recycling and manufacturing, transit, trucking and warehousing, and wholesale trade are a large component of these facilities. There is a potential for metals loadings from these types of facilities, especially metal plating, transit, and recycling facilities. Facilities enrolled under this permit are required to sample runoff and report monitoring data twice annually. A review of the available monitoring data demonstrates that several industrial facilities are exceeding applicable CTR values and are therefore a source of metals loadings to the Los Angeles River. This finding is supported by Stenstrom et al. in their final report on the industrial storm water monitoring program under the existing general permit. In the summary of existing data, the report found that although the data collected by the monitoring program were highly variable, the mean values for copper, lead and zinc were 1010, 2960, and 4960 µg/L, respectively (Stenstrom et al., 2005). During dry weather, the potential contribution of metals loadings from industrial storm water is low. Under Order No. 97-03-DWQ, non-storm water discharges are authorized only when they do not contain significant quantities of pollutants, where BMPs are in place to minimize contact with significant materials and reduce flow, and when they are in compliance with Regional Board and local agency requirements.

As of the writing of this TMDL, there are a total of 207 construction sites enrolled under the construction storm water permit. The larger sites are in the upper watershed (which includes the San Fernando Valley) and the construction in this watershed is fairly evenly divided between commercial and residential. Potential pollutants from construction sites include sediment, which may contain metals as well as metals from construction materials and the heavy equipment used on construction sites. During wet weather, runoff from construction sites has the potential to contribute metals loadings to the river. In their final report to State Board, Raskin et al. found that building materials and construction waste exposed to storm water can leach metals and contribute metals loadings to waterways (Raskin et al., 2004). During dry weather, the potential contribution of metals loadings is low. Under Order No. 99-08-DWQ, discharges of non-storm water are authorized only where they do not cause or contribute to a violation of any water quality standard and are controlled through implementation of appropriate BMPs for elimination or reduction of pollutants.

4.1.3. Other NPDES Permits

An individual NPDES permit is classified as either major or minor. The discharges flows associated with minor individual NPDES permits and general NPDES permits are typically less than 1 million gallons per day (MGD). Many of these are for episodic discharges rather than continuous flows.

Major Individual NPDES Permits

There are three major NPDES facilities in addition to the POTWs. These permits include storm water discharges and would therefore exert the greatest potential influence on metals loadings during wet weather.

Pacific Terminals LLC Tank Farm has a permitted discharge of up to 4.32 mgd of hydrostatic test water, fuel equipment wash water and storm water runoff to Compton Creek. This permit contains effluent limits for metals, but since the permit was issued prior to the adoption of CTR, there is the potential for the facilities to discharge metals in exceedance of the numeric targets. This permit is scheduled for renewal in 2005.

The Boeing Company Santa Susana Field Lab discharges up to 160 mgd of storm water (based on the 24-hour duration, 10 year return storm event) mixed with industrial wastewater to Bell Creek via two discharge points. Discharges from these two points have a low potential to contribute to metals loading because the permit contains CTR-based effluent limits, based on a total hardness of 100 mg/l or other hardness values when applicable. However, storm water is also discharged to Bell Creek through another discharge point, for which there are no effluent limitations for metals. There is a potential for metals loadings from this point. The permit requires monitoring and the imposition of effluent limits if monitoring indicates reasonable potential.

The Metropolitan Transit Authority has a permit to discharge treated wastewater from the underground construction activities (site water, storm water, and groundwater generated from dewatering activities) of the Eastside Light Rail Transit (ELRT) Project. Wastewater that is not discharged to the municipal sanitary sewer will be discharged to the Los Angeles River through sixteen outfalls. The maximum permitted cumulative discharge from the outfalls is 4.032 mgd. There is a low potential for loadings from this discharge because the permit contains CTR-based effluent limits and wastewater will be treated for metals.

Minor Individual NPDES Permits

Minor permits cover miscellaneous wastes such as ground water dewatering, swimming pool wastes, and ground water seepage. Some of these permits contain effluent limits for metals. However, some of these permits were issued prior to the adoption of CTR and there is the potential for these facilities to discharge metals in exceedance of the numeric targets in this TMDL. There are 15 minor NPDES permits in the Los Angeles River watershed.

Other General NPDES Permits

Pursuant to 40 CFR parts 122 and 123, the State Board and the Regional Boards have the authority to issue general NPDES permits to regulate a category of point sources if the sources: involve the same or substantially similar types of operations; discharge the same type of waste; required the same type of effluent limitations; and require similar monitoring. The Regional Board has issued general NPDES permits for the following categories of discharges: construction dewatering, non-process wastewater; petroleum fuel cleanup sites; volatile organic compounds (VOCs) cleanup sites; potable water; and hydrostatic test water.

The general NPDES permit for Discharges of Groundwater from Construction and Project Dewatering to Surface Waters (Order No. R4-2003-0111) covers wastewater discharges, including but not limited to, treated or untreated groundwater generated from permanent or temporary dewatering operations. Currently, there are 29 dischargers enrolled under this Order in the Los Angeles River watershed. There are two dischargers with permits for the Discharge of Treated Ground Water from Construction Dewatering (Order No. 97-043) and four dischargers with permits for the Discharge of Untreated Ground Water from Construction Dewatering (Order No. 97-045). There are five discharges enrolled under general NPDES permit for Discharges of Nonprocess Wastewater to Surface Waters (Order No. R4-2004-0058) which covers waste discharges, including but not limited to, noncontact cooling water, boiler blowdown, air conditioning condensate, water treatment plant filter backwash, filter backwash, swimming pool drainage, and/or groundwater seepage. There are four dischargers enrolled under Order No. 98-055 specifically for non-contact cooling water.

Discharges from construction dewatering and nonprocess wastewater have a low potential to contribute to metals loadings. In order to be eligible to be covered under this Order, a discharger must perform an analysis using a representative sample of the groundwater or nonprocess wastewater to be discharged. The sample is analyzed and the data compared to the water quality screening criteria for metals, which are based on the CTR criteria. The permit includes effluent limitations for metals, which are based on the CTR. For the hardness dependent metals, the effluent limitations are based on site-specific hardness values.

The general NPDES permit for Treated Groundwater and Other Wastewaters from Investigation and/or Cleanup of Petroleum Fuel-Contaminated Sites to Surface Waters (Order No. R4-2002-0125) covers discharges, including but not limited to, treated groundwater and other wastewaters from the investigation, dewatering, or cleanup of petroleum contamination arising from current and former leaking underground storage tanks or similar petroleum contamination. Currently, there are seven dischargers enrolled under this Order in the Los Angeles River watershed. There are approximately six dischargers enrolled under the general NPDES permit for Discharges of Treated Groundwater from Investigation and/or Cleanup of VOCs-Contaminated Sites to Surface Waters (Order No. R4-2002-0107) which includes but is not limited to, treated groundwater and other wastewaters from the investigation, cleanup, or construction dewatering of VOCs only (or VOCs commingled with petroleum fuel hydrocarbons) contaminated groundwater.

Discharges from site cleanup operations have a low potential to contribute to metals loadings. In order to be eligible to be covered under these Orders, the discharger must demonstrate that a representative sample of the contaminated groundwater to be treated and discharged does not exceed the water quality screening criteria for metals, which are based on the CTR criteria. In addition, the permit includes effluent limitations for lead. The effluent limitations for lead are based on the CTR default hardness value of 100 mg/L.

The general NPDES permit for Discharges of Groundwater from Potable Water Supply Wells to Surface Waters (Order No. R4-2003-0108) covers discharges of groundwater from potable supply wells generated during well purging, well rehabilitation and redevelopment, and well drilling, construction and development. Currently, there are 25 dischargers enrolled under this Order in the Los Angeles River watershed. The general NPDES permit for Discharges of Low Threat Hydrostatic Test Water to Surface Waters (Order No. R4-2004-0109) covers waste discharges from hydrostatic testing of pipes, tanks, and storage vessels using domestic/potable water. Currently, there are eight dischargers enrolled under this Order in the Los Angeles River watershed.

Discharges of potable water from water supply wells and from hydrostatic testing have a low potential to contribute metals loadings to the Los Angeles River or its tributaries, since these pollutants are not expected to be in potable water. In order to be eligible to be covered under this Order, the discharger must demonstrate that concentrations are not greater than the maximum contaminant levels (MCLs). The MCLs are health protective drinking water standards adopted by the California Department of Health Services. The MCLs define the maximum permissible level of a contaminant in water delivered to any user of a public drinking water supply system. In general, the MCLs for the metals are greater than the numeric targets.

4.1.4. Summary of NPDES Permits

A summary of permit requirements and potential for significant contribution to water quality impairments are presented in Table 4-2.

Table 4-2. Source assessment summary.

Type of NPDES Permit	Number of Permits	Screening for Pollutants	Permit Limits for metals?	Potential for significant contribution
Publicly Owned Treatment Works	6	Yes	Yes	High
Municipal Storm water	3	Yes	No	High
Industrial Storm water	1307	Yes	No	High
Construction Storm water	204	Yes	No	High
Other Major NDPES Discharges	3	Yes	Yes	Medium
Minor NPDES Discharges	15	Yes	varies	Varies
Other General NPDES Discharges				
Construction Dewatering	35	Yes	Yes	Low
Non-Process Wastewater	9	Yes	Yes	Low
Petroleum Fuel Cleanup Sites	7	Yes	Lead only	Low
VOCs Cleanup Sites	6	Yes	Lead only	Low
Hydrostatic Test Water	8	Yes	Not CTR	Low
Potable Water	25	Yes	Not CTR	Low
Total	**1628**			Low

4.2. Quantification of loads

4.2.1. Dry-Weather Loadings

During low flow periods the three major POTWs typically account for 70% to 100% of the total volume of discharge in the river. The remaining dry weather flow represents a combination of tributary flows, groundwater discharge, flows from other permitted NPDES discharges within the watershed (Table 4-4), and dry-weather urban runoff.

The total metals loads from the Tillman, Burbank and Glendale WRPs were estimated using monthly flow and effluent concentration data provided as part of the annual self monitoring reports (Table 4-3). On a daily basis these three POTWs contribute approximately 0.2 kg/d of cadmium, 4.5 kg/d of copper, 0.5 kg/d of lead and 12.8 kg/d of zinc to the Los Angeles River.

Table 4-3. Total annual metals loadings from three POTWs (kg/yr).

Metal	Facility	1998	1999	2000	2001	2002	Ave
Cadmium	Tillman	105	59	53	33	33	57
	Burbank2	7	4	14	13	1	8
	Glendale	19	16	15	16	16	16
	Total	**131**	**79**	**82**	**62**	**50**	**81**
Copper	Tillman	1427	1292	1690	1574	1260	1449
	Burbank2	27	24	37	8	66	32
	Glendale	119	135	166	205	150	155
	Total	**1573**	**1451**	**1893**	**1787**	**1476**	**1636**
Lead	Tillman	122	105	120	94	86	105
	Burbank2	46	26	64	95	3	47
	Glendale	29	30	32	24	24	28
	Total	**197**	**161**	**216**	**213**	**113**	**180**
Zinc	Tillman	4134	2955	4398	3671	2994	3630
	Burbank2	157	138	238	353	207	219
	Glendale	1002	814	771	801	749	827
	Total	**5293**	**3907**	**5407**	**4825**	**3950**	**4676**

To assess the relative contributions of metals during dry weather, sampling was conducted in September 2000 and July 2001. The monitoring consisted of synoptic sampling of flow and concentration from the three POTWs, the headwaters of the tributaries, and 49 storm drains on September 11-12, 2000 (Ackerman et al., 2003). This was followed up by another synoptic survey in July 2001. In this second survey, more focus was put on the storm drains, and the number of storm drains sampled during this event was 84. Table 4-4 provides the summary results from these two surveys in terms of total mass for each metal and the relative contribution from each major source.

Table 4-4. Relative loading (%) of total recoverable metals by source to the Los Angeles River during dry-weather conditions (Based on data from 2000 and 2001 Los Angeles River synoptic surveys).

Sources	Cadmium		Copper		Lead		Zinc	
	2000	2001	2000	2001	2000	2001	2000	2001
Tributaries	7%	6%	8%	5%	10%	6%	5%	3%
POTWs	59%	39%	69%	38%	55%	41%	81%	51%
Dry Weather Runoff	34%	55%	23%	57%	35%	53%	14%	46%
Total Mass (kg/d)	0.3	0.3	5.6	6.9	2.8	2.4	14.8	20.4

The POTWs contribute a fairly large percentage of the total dry-weather metals loadings. The concentrations of metals in the POTWs may be low, but loadings are high because the POTW flows are large. The storm drains also contribute a large percentage of the loadings. Storm drain flows are typically low during dry weather, but concentrations of metals in urban runoff may be quite high. In calculating the dry-weather loadings estimates in Table 4-4, non-detects were treated as ½ the detection limit. Lead and to a lesser extent for cadmium were generally below detection limits on both sampling dates. We did not treat detection limits as zeros because these metals have been frequently detected in POTW effluent monitoring data supplied by the dischargers and in dry-weather urban runoff, as reported by LACDPW.

During dry weather, background concentrations may come from tributaries which drain the hills of the Angeles National Forest and the open areas of the Santa Monica Mountains. The flows from these areas are relatively small during dry weather and much of it is captured behind dams. The metals concentrations in flows from these areas are also likely to be low. The estimated loadings from the tributaries were generally less than 10%. This may be an overestimate, since the sites for the tributary samples were not selected for the purpose of defining natural background conditions. Rather sites were selected to define conditions at the boundary of the listed reaches and in many cases there are inputs from storm drains upstream of the listed reaches.

4.2.2 Wet-Weather Loadings

Most of the annual metals loadings to the Los Angeles River are associated with wet weather (Stein et al., 2003). In addition to the MS4 and Caltrans storm water permits, there are more than one thousand industrial facilities in the Los Angeles River watershed that are enrolled under the statewide NPDES general storm water permit for industry (Table 4-1). However, the data collected under the monitoring program for this permit are not of sufficient frequency or quality to be used to estimate loadings (Duke et al., 1998). Therefore, to assess total storm water loadings we relied on the LACDPW storm water monitoring data from the mass emission station at Wardlow (LACDPW, 2000). Table 4-5 summarizes the aggregate seasonal loads from flow-weighted composites of multiple storms sampled between 1996 and 2002.

Wet weather loadings can vary by an order of magnitude depending on the rainfall and size of storms in a given year. In a report to State Board, SCCWRP estimated the mass loadings for a typical year (Stein et al., 2003). In this report, data are modeled from 30-year average rainfall, land use runoff data, and land use distribution data. These values are generally consistent with the average loadings calculated from the LACDPW mass emission stations (Table 4-5).

Table 4-5. Seasonal storm water total recoverable metals loadings (kg/yr) to Los Angeles River watershed. Data are from LACDPW and Stein et al., 2003.

LACDPW	Cadmium	Copper	Lead	Zinc
96/97	-	3,629	3,760	16,692
97/98	-	36,741	94,347	210,012
98/99	-	1,075		6,078
99/00	-	286	207	1,012
00/01	-	1,409	879	5,645
01/02	-	514	106	1022
Average	-	7,276	19,860	40,077
SCCWRP	**Cadmium**	**Copper**	**Lead**	**Zinc**
Typical year	62	6,960	2,304	42,479

Average annual POTW loadings (Table 4-3) can be compared to the typical storm water loadings (Table 4-5) to provide an indication of the relative contributions from these sources. On an annual basis, storm water contributes about 40% of the cadmium loading, 80% of the copper loading, 95% of the lead loading, and 90% of the zinc loading.

Atmospheric deposition is another potential source of metals to the watershed. Deposition of metals to the surface area of the Los Angeles River watershed may be substantial, on the order of several thousand kilograms per year (Sabin et al., 2004). Direct atmospheric deposition during dry weather was quantified by multiplying the surface area of the river times the rate of atmospheric deposition. These numbers (Table 4-6) are generally small because the actual surface area of the river system is small. Direct deposition of metals is insignificant relative to either the annual dry-weather loadings or the total annual loadings. Indirect atmospheric deposition reflects the process by which metals deposited on the land surface may be washed off during rain events and be delivered to the Los Angeles River and tributaries. Not all the metals deposited on the land from the atmosphere are loaded to the river. Estimates of metals deposited on land (Table 4-6) are much higher than estimates of loadings to the river (Table 4-5). Sabin et al. (2004) calculated the ratio of wet-weather water runoff to indirect atmospheric deposition as 19% for copper, 9% for lead, and 22% for zinc. The loadings of metals associated with indirect atmospheric deposition are accounted for in the estimates of the storm water loadings.

Table 4-6. Estimates of dry weather direct and indirect deposition (kg/year). Source: Sabin et al., 2004.

Type of deposition	Copper	Lead	Zinc
Indirect	16,000	12,000	80,000
Direct	3	2	10

5. LINKAGE ANALYSIS

Information on sources of pollutants provides one part of the TMDL equation. To determine the effects of these sources on water quality, it is also necessary to determine the assimilative capacity of the receiving water. Variations between wet and dry weather can strongly affect the delivery of metals to the Los Angeles River and the assimilative capacity of the river to accommodate these loadings so that standards are met. Given the differences in sources and flows between dry and wet weather, two distinct approaches for the linkage analysis were taken. This section describes the use of hydrodynamic and water quality models to assess the effects of metals loadings in the Los Angeles River on water quality under both dry and wet weather conditions.

5.1 Development of the Dry-Weather Model

The Environmental Fluid Dynamics Code 1-D (EFDC1D) was used to model the hydrodynamic characteristics of the Los Angeles River and its tributaries (Table 5-1) during dry weather. EFDC1D is a one dimensional variable cross-section model for flow and transport in surface water systems. For simulation of the water quality within the Los Angeles River, the EFDC model was linked to the Water Quality Analysis Simulation Program (WASP5). The details associated with development of the dry-weather model are presented in Appendix I.

Table 5-1. Los Angeles River segments modeled for dry-weather linkage analysis.

Los Angeles River Mainstem	Los Angeles River Tributaries
Reach 6: above Sepulveda Flood Control Basin	Bell Creek
Reach 5: within Sepulveda Basin	Tujunga Wash
Reach 4: Sepulveda Dam to Riverside Dr	Burbank Western Channel
Reach 3: Riverside Dr to Figueroa St	Verdugo Wash
Reach 2: Figueroa St to Carson St	Arroyo Seco
Reach 1: Carson St to Estuary	Rio Hondo River
	Compton Creek

To support the model development a comprehensive set of in-stream hydrodynamic and water quality data were collected in the late summer of 2000 (September 11-12) and summer of 2001 (July 29-30) as part of the synoptic surveys. These data were used as model input as well as for comparison to model results during calibration and validation. Flow and water quality measurements were used as model input to represent the tributary discharges and dry-weather discharges from storm drains. In addition, instream flow and water quality measurements were compared with model results during model calibration, validation and comparison.

5.1.1. Calibration and Validation of the Dry-Weather Model - Flow. The LA River hydrodynamic model was calibrated for low-flow conditions measured on the dates of the first intensive data collection (September 10 and 11, 2000) and then validated to the flow conditions measured during the second monitoring effort (July 29-30, 2001).

There are four stream gages along the mainstem of the Los Angeles River (Figure 5). The upper-most station (designated F300-R) is in Reach 4 of the Los Angeles River below Tillman plant. The lowest station is the Wardlow gage station (designated F319-R), which is below the confluence of all tributaries within the Los Angeles River and all simulated point sources. The variability in daily flow measured at these gages is high. On September 11, 2000 the measured flows ranged from 50 to 120 cfs at the upper most station to 135 to 200 cfs at the lowest station. On July 29, 2001 the measured flow ranged from 50 and 75 cfs at the upper-most station and 170 to 200 cfs at the lowest station. The long-term median flows (12-year) at Tujunga, Firestone and Wardlow are 78 cfs, 124 cfs, and 145 cfs respectively. The days selected for the calibration and validation of the model are generally representative of the low-flow condition. A comparison of the measured flow on September 11 at these four stations to the modeled dry-weather flow is presented in (Figure 6).

5.1.2. Comparison of Dry-Weather Model - Water Quality. Model results were compared to observed data. The first comparison of the dry-weather water quality model was performed using field measurements collected on September 10, and 11, 2000 (Tables 5-2). The second comparison of the dry-weather water quality model was performed using field measurements from July 29 and 30, 2001 (Tables 5-3).

Table 5-2. Flow (cfs) and concentrations of total recoverable metals (µg/l) used in model comparison based on samples collected on September 10 and 11, 2000.

POTWs	Flows	Cd[1]	Cu	Pb[2]	Zn
Tillman POTW					
Direct Discharge	53.3	0.5	13	5	39
Japanese Gardens	7.4	0.5	13	5	39
Recreation Lake	27.0	0.5	13	5	39
Wildlife Lake	9.1	0.5	13	5	39
Glendale POTW	14.4	0.5	5	5	30
Burbank POTW	14.3	0.5	18	5	52
Tributaries	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Bell Creek	4.3	0.5	15	5	5
Tujunga Wash	0.7	0.5	18	5	16
Burbank Western Channel	1.4	0.5	18	5	52
Verdugo Wash	2.8	0.5	14	19	41
Arroyo Seco	3.7	0.5	5	5	5
Compton Creek	3.1	0.5	5	5	11

1 – Detection limit for cadmium was 1 µg/L. Non-detects were treated as ½ the detection limit.

2 - Detection limit for lead was 10µg/L. Non-detects were treated as ½ the detection limit.

Table 5-3. Flows (cfs) and concentrations of total recoverable metals (µg/l) used in model comparison based on samples collected on July 29 and 30, 2001.

POTWs	Flows	Cd[1]	Cu	Pb[2]	Zn
Tillman POTW					
Direct Discharge	14.4	0.5	12.5	5	50.6
Japanese Gardens	7.0	0.5	5	5	35.1
Recreation Lake	27.0	0.5	14.7	5	67.2
Wildlife Lake	8.8	0.5	5	5	35.1
Glendale POTW	14.3	0.5	20.1	5	43.1
Burbank POTW	8.1	0.5	16.2	5	69.7
Tributaries	**Flows**	**Cd[1]**	**Cu**	**Pb[2]**	**Zn**
Bell Creek	2.7	0.5	6.9	5	5
Tujunga Wash	0.4	0.5	32.2	5	17.9
Burbank Western Channel	1.4	0.5	16.2	5	69.7
Verdugo Wash	2.2	0.5	17.9	5	25.3
Arroyo Seco	3.3	0.5	5	5	1.08
Rio Hondo	0.5	0.5	18.2	25.5	33.2
Compton Creek	1.8	0.5	9.2	5	24.9

1 – Detection limit for cadmium was 1 µg/L. Non-detects were treated as ½ the detection limit.
2 - Detection limit for lead was 10 µg/L. Non-detects were treated as ½ the detection limit.

The model performs well in predicting the average concentrations of these metals (Figure 7.). These can be compared to the long-term averages as represented by the City of Los Angeles Watershed monitoring program (Figures 3a – 3d). On both days, the model indicated that concentrations were below the CTR standards. This is consistent with our expectation, since the POTWs that provide most of the dry-weather flows to the river are generally discharging effluent that meets the water quality standards. The model is not able to represent all the temporal and spatial variability observed in the in-stream metals concentrations due to the inherent variability and uncertainty associated with estimates of storm drain flow and concentrations. The variability in concentrations seen over time in the City's data set suggests that episodic exceedances in water quality are likely to be a result of irregular inputs from urban runoff rather than the more stable POTW flow. The model provides a reasonable assurance that we understand the relationship between in-stream loads and targets.

5.2 Development of the Wet-Weather Model

Wet-weather sources are generally associated with wash-off of pollutant loads accumulated on the land surface. During a rainy period, these loads are delivered to the waterbody through creeks and storm water collection systems. USEPA's Loading Simulation Program in C++ (LSPC) was selected to simulate the hydrologic processes and pollutant loading from the Los Angeles River watershed. LSPC is a recoded C++ version of USEPA's Hydrologic Simulation Program-Fortran (HSPF). The details associated with the development and validation of the wet-weather model system are presented in Appendix II.

The Los Angeles River watershed area was divided into thirty-five smaller, discrete sub-watersheds for modeling and analysis (Figure 8). This subdivision was primarily based on the stream and storm sewer networks and topographic variability. Other factors such as the presence of existing watershed boundaries, consistency of land use, and the locations of existing monitoring stations were also considered in delineation. Each delineated subwatershed was represented with a single stream reach from the National Hydrography Dataset (NHD) stream network. Information on the length, slope, mean depth and channel widths for each reach was used to route flow and pollutants through the watershed.

Two sources of land use data were used in this modeling effort. The primary source of data was the Southern California Association of Governments (SCAG) 2000 land-use dataset that covers Los Angeles County. This data set was supplemented with land-use data from the 1993 USGS Multi-Resolution Land Characteristic data to fill data gaps. Land-use categories were grouped into seven categories for modeling (Residential, Commercial, Industrial, Open, Agriculture, Water, and Other). Table 5-4 presents the land use distribution within the watershed for each of the 35 sub-watersheds.

Hourly rainfall data were obtained from the National Climatic Data Center for 11 weather stations located in and around the Los Angeles River watershed for October 1998 through December 2001 (Figure 9). The USDA's STATSGO soils data base served as a starting point for hydrologic parameters such as infiltration and groundwater flow parameters. This was augmented with information from other modeling applications in the area (i.e., for Santa Monica Bay, Ballona Creek, San Gabriel River). These starting values were refined through the calibration process.

Loading processes for metals (copper, lead, and zinc) for each land use were represented in LSPC through their associations with sediment. The accumulation and washoff of sediments were modeled using the SDMNT module for pervious lands and the SOLIDS module for impervious lands. Sediments washed off by rain are delivered to the stream channel by overland flow. Processes such as transport, deposition and scour of sediments in the stream channels were modeled using the SEDTRN module.

The model was then used to simulate the in-stream total suspended solids concentrations. Metals associated with these sediments were simulated using the LSPC water quality module. The relationships between sediment and metals (copper, lead and zinc) were parameterized as potency factors developed by SCCWRP (Ackerman et al., 2004). Potency factors were defined for copper, lead and zinc for each of seven land-uses categories (agriculture, commercial, industrial, residential, water, other, and open).

Table 5-4. Land use distribution in the watershed (square miles).

Watershed	Residential	Commercial	Industrial	Open	Agriculture	Water	Other	Total
1	8.55	0.87	0.52	7.44	0	0	0.32	17.69
2	7.91	0.91	0.28	5.17	0.08	0.04	0.44	14.83
3	4.49	0.60	1.55	15.75	0.20	0	0	22.59
4	4.53	1.23	0.87	5.96	0.40	0.04	0.08	13.12
5	9.86	1.91	2.86	6.52	0	0	0.32	21.47
6	8.67	1.39	0.60	1.67	0.08	0	0	12.41
7	8.11	1.15	3.38	8.23	0.24	0.28	0.12	21.51
8	10.94	1.91	0.44	3.34	0.24	0.12	0.36	17.34
9	17.93	3.58	2.78	4.89	0.48	0.16	0.04	29.86
10	0.76	0	0	33.00	0.04	0.20	0	34.00
11	7.04	1.67	1.67	6.88	0.48	0	0.08	17.81
12	7.59	1.59	1.19	0.76	0.16	0	0	11.29
13	4.10	0.36	2.19	120.09	0.12	0.08	0	126.9
14	0.56	0.04	0.24	20.32	0.28	0	0	21.43
15	3.14	0.4	2.62	3.74	0.16	0	0	10.06
16	6.68	1.03	0.95	0.28	0	0	0	8.95
17	5.49	1.59	1.95	0.52	0	0	0	9.54
18	0.95	0.04	0	0.08	0	0	0	1.07
19	9.42	1.55	5.49	12.21	0.12	0	0.20	28.99
20	6.64	1.67	1.59	2.98	0.08	0.04	0.08	13.08
21	9.86	1.35	0.76	13.04	0	0	0.08	25.09
22	2.58	0.28	0.72	4.49	0	0	0	8.07
23	17.5	2.15	2.15	28.39	0.08	0	0.04	50.30
24	10.66	2.07	3.82	7.67	0.08	0	0.28	24.57
25	16.62	6.76	17.5	4.49	0.08	0	0.24	45.69
26	0.00	0.04	0.04	10.42	0	0	0	10.50
27	9.15	1.55	2.74	15.35	0.56	0.32	0.12	29.78
28	16.06	2.86	1.47	12.29	0.36	0	0	33.04
29	10.74	2.58	1.19	0.99	0	0	0.04	15.55
30	18.37	4.29	2.11	1.99	0.32	0.04	0.12	27.24
31	6.16	1.67	2.35	2.58	0.40	0.20	0	13.36
32	10.30	3.10	5.05	2.27	0.64	0	0.04	21.39
33	23.34	6.16	9.3	1.03	0.08	0.04	0.16	40.12
34	14.04	3.86	3.66	1.63	0.24	0	0.12	23.54
35	6.12	1.87	2.51	1.39	0.04	0.20	0.08	12.21
Total Area	304.86	64.08	86.54	367.85	6.04	1.76	3.36	834.39
Percent of Total Area	36.54%	7.68%	10.37%	44.08%	0.72%	0.21%	0.40%	834.39

5.2.1. Calibration and Validation of the Wet-Weather Model – Flow. Hydrology is the first model component calibrated because estimation of metals loading relies heavily on flow prediction. The hydrology calibration involves a comparison of model results to in-stream flow observations at selected locations. Key considerations in the hydrology calibration included the overall water balance, the high-flow/low-flow distribution, storm flows, and seasonal variation. Calibration was focused on flow gages with data for the entire period of record, including a gage in the upper portion of the watershed (Los Angeles River at Tujunga Avenue) and a gage in the more urban area of the watershed (Rio Hondo above Stuart and Gray Road). Validation was performed using data from 6 other gages in the water shed (Table 5-5). The validation essentially confirmed the applicability of the hydrologic parameters derived during the calibration process.

Table 5-5. Stream gage stations used for calibration and validation of flow data.

Gage Number	Station description	Use
F-45B-R	Rio Hondo above Stuart and Gray Road	Calibration
F-300-R	Los Angeles River at Tujunga Avenue	Calibration
F-285-R	Burbank Western Stormdrain at Riverside Drive	Validation
F-37B-R	Compton Creek near Greenleaf Drive	Validation
F252-R	Verdugo Wash at Estelle Avenue	Validation
F57C-R	Los Angeles River above Arroyo Seco	Validation
F34D-R	Los Angeles River below Firestone Boulevard	Validation
F319-R	Los Angeles River below Wardlow	Validation

Figure 10a depicts a time-series plot of modeled and observed daily flows at the bottom of the watershed (Los Angeles River below Wardlow River Rd.). A regression of average monthly model-predicted and observed flows (Figure 10b) indicates a slight under-prediction of measured flows. This under-prediction is due mostly to events occurring in the winter of 1992-1993 and 1994-1995 (Figure 10a). Flow volumes generated by the model were compared under different flow regimes and seasonal periods (Table 5-6). For higher flows (highest 10%), the model performs well in predicting storm volumes with an error of –4%. However, for lower flows (lowest 50%) the model is less accurate in predicting flow volumes (–17%) due largely to the inability of the model to simulate variability in point sources and dry-weather urban runoff. A review of the time-series plots also shows that the model is less accurate for low-flow conditions. This is justification for a separate approach for expressing dry-weather allocations and compliance assurance. Hydrology calibration and validation results, including time series plots and relative error tables, are presented for each gage in Appendix II.B.

Table 5-6. Volumes (acre-feet) and relative error of modeled flows versus observed flow for the Los Angeles River at Wardlow (10/1/1989 – 3/3/1998).

Flows Volumes	Simulated Flow	Observed Flow	Error (%)	Recommended Criteria (%)
Total Stream Volume	394,911	431,200	-9	±10
Highest 10% flows	307,787	320,578	-4	±15
Lowest 50% flows	39,309	46,158	-17	±10
Summer flow volume	20,205	24,797	-23	±30
Fall flow volume	70,661	63,764	10	±30
Winter flow volume	275,206	311,727	-13	±30
Spring flow volume	28,840	30,912	-7	±30

Overall, during model calibration the model predicted storm volumes and storm peaks well. Since the runoff and resulting streamflow are highly dependent on rainfall, occasional storms were over-predicted or under-predicted depending on the spatial variability of the meteorological and gage stations. The validation results also showed a good fit between modeled and observed values, thus confirming the applicability of the calibrated hydrologic parameters to the Los Angeles River watershed.

5.2.2. Calibration and Validation of the Wet-Weather Model - Pollutant Loading. Total suspended solids (TSS) and the potency factors used to determine the relationships between sediment and total recoverable metals were developed and calibrated by SCCWRP at specific watersheds in the Los Angeles area. These were validated for use in the Ballona Creek watershed. We did not re-calibrate these parameters for the Los Angeles River. Use of these parameters for the Los Angeles River was validated by comparing model output to in-stream water quality measurements collected during storms. In the validation process, we tested the ability of the model to predict 1) the event mean concentration (EMC) at the watershed scale, 2) the EMC at the sub-watershed scale and 3) changes in the instantaneous concentrations over the course of a storm.

The EMCs predicted by the model at the bottom of the watershed were comparable to EMCs calculated from flow-weighted composite measurements made by the LACDPW at the Wardlow Station (1994-2001). To evaluate the model performance at the sub-watershed scale, EMCs were calculated for Verdugo Wash, Arroyo Seco, Los Angeles River above Arroyo Seco and Los Angeles River at Wardlow based on storm water sampling that was conducted in 2001. Two to three storms were sampled at each of these subwatersheds. TSS and metals concentrations were measured numerous times (8 to 12) over the course of the individual storms. There is quite a bit of variability in the EMCs calculated from the monitoring data. The predicted EMCs for TSS were generally within the range of the calculated EMCs. The predicted EMCs for copper, lead and zinc were generally higher than the calculated EMCs. The model was not able to adequately represent the variability in concentrations within a storm at the sub-watershed scale.

We conclude that the wet-weather model performs better at the watershed level than at the sub-watershed level. The model provides reasonable estimates of storm water EMCs, but is not refined enough to predict instantaneous storm water concentrations. The EMCs for TSS were comparable to estimates based on storm water composites. The EMCs for copper, lead and zinc tend to be higher than predicted from storm water composite samples.

5.3 Summary of Linkage Analysis

The dry-weather model is able to predict flow and concentration in the Los Angeles River. The wet-weather model predicts storm flow reasonably well. Estimates of storm loadings predicted by the wet-weather model tend to be higher than loadings estimated from monitoring data. However, as described in Section 6.1 and 6.3, neither of the dry- or wet-models were used in developing load capacity. The wet-weather model was only used to estimate the load allocation for open space. Since the wet-weather model predicted loads are higher than measured loads, this provides a conservative assessment of the contribution from open space, which can be applied to the margin of safety. While not used to develop load capacity, the models should prove useful in evaluating management scenarios to help achieve load reductions in TMDL implementation.

6. Total Maximum Daily Loads

In this section, we develop the loading capacity and allocations for metals in the Los Angeles River. EPA regulations require that a TMDL include waste load allocations (WLAs), which identify the portion of the loading capacity allocated to existing and future point sources (40 CFR 130.2(h)) and load allocations (LAs), which identify the portion of the loading capacity allocated to nonpoint sources (40 CFR 130.2(g)). As discussed in previous sections, the flows, sources of metals and the relative magnitude of inputs vary between dry-weather and wet-weather periods. TMDLs are developed to address both dry- and wet-weather conditions.

6.1 Dry-Weather Loading Capacity and TMDLs

Dry-weather TMDLs are developed for the following pollutant waterbody combinations:

- Copper for the Los Angeles River Reaches 1, 2, 3, 4, and 5, Burbank Western Channel, Compton Creek, Rio Hondo Reach 1 and Tujunga Wash. Allocations are developed for upstream reaches and tributaries to meet TMDLs in downstream reaches. No copper allocations are assigned to reaches above Rio Hondo Reach 1 because little or no flow from these reaches enters Rio Hondo Reach 1 during dry weather.
- Lead for the Los Angeles River Reaches 1, 2, 3, 4, and 5, Burbank Western Channel, Rio Hondo Reach 1, and Compton Creek. Allocations are developed for upstream reaches and tributaries to meet TMDLs in downstream reaches. Concentration-based allocations are developed for lead in Monrovia Canyon Creek. Lead allocations are not assigned to other non-impaired reaches above Rio Hondo Reach 1 because little or no flow from these reaches enters Rio Hondo Reach 1 during dry weather.
- Zinc for Rio Hondo Reach 1. Allocations are only developed for Rio Hondo Reach 1.
- Selenium for Reach 6, Aliso Creek, Dry Canyon Creek and McCoy Canyon Creek. Concentration-based allocations are only developed for Reach 6 and its tributaries.

The dry-weather loading capacity for each reach is determined by multiplying the reach-specific dry-weather target expressed as total recoverable metals (Table 3-2) by a critical flow assigned to each reach.

Dry-weather flows in the Los Angeles River are influenced highly by the amount of effluent discharge and by the presence of dams on the tributaries. Critical flows for each reach were established from the long-term flow records (1988-2000) generated by stream gages located throughout the watershed (Figure 5). In general, the median flow measured at each gage was selected as the critical flow. In areas where there were no flow records, an area-weighted approach was used to assign flows.

Critical flows for Verdugo Wash, Rio Hondo and Compton Creek were obtained directly from stream gages. The critical flow for Burbank-Western Channel was obtained directly from the stream gage minus the median flow from Burbank WRP. The stream gages for the Tujunga Wash and Arroyo Seco are located at the dams for these tributaries. The critical flows for these tributaries were thus calculated by multiplying the ratio of the area of their subwatersheds to the area above their dams by the median flow measured at their gages. The critical flow for Bell

Creek was calculated by multiplying the ratio of the Bell Creek subwatershed to the combined area of the tributary watersheds by the combined median flow of the tributaries. The critical flows for each reach of the river were obtained by multiplying the ratio of the area of the subwatershed for each reach to the total watershed area by the total median storm drain and tributary flow. The total median storm drain and tributary flow (34 cfs) is calculated by subtracting the existing combined median flow of the three POTWs (111 cfs) from the existing total median flow of the river as measured at Wardlow (145 cfs).

In reaches with POTW discharge, the critical flow is equal to the total median storm drain and tributary flow plus the design capacity of the POTW that discharges to the reach. To account for flow from Tillman, the design flow of 124 cfs was applied to Reach 4. Similarly, a design flow of 31 cfs was applied to Reach 3 to account for flows from the Glendale plant and a design flow of 14 cfs was applied to the Burbank Western Channel to account for flows from the Burbank plant. Because these three major POTWs account for the majority of flow during dry weather, dry-weather flow is relatively constant. The critical flow for the entire river is thus equal to the design capacity of the three POTWs (169 cfs) plus the existing median flow from the storm drains and tributaries (34 cfs). Critical dry-weather flows are presented in Table 6-1.

Table 6-1. Critical dry-weather flows used to set dry-weather loading capacity.

Los Angeles River	Area of Subwatershed (acres)	Median Non-POTW Flow (cfs)	POTW design flow (cfs)	Critical Flow (cfs)
LA River Reach 6	53,860	7.20	-	7.20
LA River Reach 5	5593	0.75	-	0.75
LA River Reach 4	38,380	5.13	124	129.13
LA River Reach 3	36,231	4.84	31	35.84
LA River Reach 2	28,893	3.86	-	3.86
LA River Reach 1	19,330	2.58	-	2.58
Tributaries				
Bell Creek	11,357	0.79	-	0.79
Tujunga Wash	14,7448	0.15	-	0.15
Burbank-Western Channel	18,674	3.34	14	17.3
Verdugo Wash	16,117	3.30	-	3.3
Arroyo Seco	32,271	0.58	-	0.58
Rio Hondo Reach 1	96,425	0.50	-	0.50
Compton Creek	25,506	0.90	-	0.90
Total	530,086	34	169	203

The dry-weather loading capacity for each impaired reach based on these critical flows is identified in Table 6-2. Loading capacities for impaired reaches include the critical flows for upstream reaches. The dry-weather loading capacity for Reach 5 includes flows from Reach 6 and Bell Creek, the dry-weather loading capacity for Reach 3 includes flows from Verdugo Wash, and the dry-weather loading capacity for Reach 2 includes flows from Arroyo Seco.

Table 6-2. Dry-weather loading capacity (TMDL) for impaired reaches and tributaries of the Los Angeles River (total recoverable metals)

Los Angeles River	Critical Flow (cfs)	Copper (kg/day)	Lead (kg/day)	Zinc (kg/day)
LA River Reach 5	8.74	0.65	0.39	
LA River Reach 4	129.13	8.1	3.2	
LA River Reach 3	39.14	2.3	1.01	
LA River Reach 2	4.44	0.16	0.084	
LA River Reach 1	2.58	0.14	0.075	
Tributaries	**Critical Flow (cfs)**	**Copper**	**Lead**	
Tujunga Wash	0.15	0.0070	0.0035	
Burbank Western Channel	17.3	0.80	0.39	
Rio Hondo Reach 1	0.50	0.015	0.0061	0.16
Compton Creek	0.90	0.041	0.020	
Total	203	12.2	5.2	0.16

6.2 Dry-Weather Allocations

Allocations are assigned to point and nonpoint sources throughout the watershed in order to meet the TMDLs for impaired reaches. Mass-based waste load allocations are developed for the three POTWs (Tillman, Glendale, and Burbank) and mass-based load allocations are developed for open space and direct atmospheric deposition. A grouped mass-based waste load allocation is developed for storm water permitees (Los Angeles County MS4, Long Beach MS4, Caltrans, General Industrial and General Construction) by subtracting the mass-based waste load and load allocations from the total loading capacity according to the following equation:

TMDL = POTW + Direct Air Deposition + Open Space + Combined Storm Water Sources **Equation (7)**

Concentration-based waste load allocations are developed for other point sources in the watershed. These other point sources have intermittent flow and calculation of mass-based waste load allocations is not possible. These sources will have a minor impact on metals loading if they are limited by concentration to the applicable CTR-based waste load allocations. In addition, these sources can provide assimilative capacity equal to or greater than their loading, so their mass-based contribution would roughly cancel out of equation 7.

6.2.1. Dry-weather waste load allocations for three POTWs. Mass- and concentration-based waste load allocations for Tillman, Los Angeles-Glendale and Burbank POTWs are developed (Table 6-3) to meet the reach-specific dry-weather targets for copper and lead (Table 3-2). For Tillman, the in-stream targets are based on conditions in Reach 4 of the Los Angeles River below the plant. For Glendale, the in-stream targets are based on conditions in Reach 3 of the Los Angeles River below the plant. For Burbank, the in-stream targets are based on conditions in the Burbank Western Channel downstream of the plant.

Table 6-3. Dry-weather waste load allocations for three POTWs (expressed as total recoverable metals)

Facility	Design Flow (cfs)	WLA	Copper	Lead
Tillman	124	Concentration-based	26 µg/L	10 µg/L
		Mass-based	7.8 kg/day	3.03 kg/day
Glendale	31	Concentration-based	26 µg/L	12 µg/L
		Mass-based	2.0 kg/day	0.88 kg/day
Burbank	14	Concentration-based	19 µg/L	9.1 µg/L
		Mass-based	0.64 kg/day	0.31 kg/day
Total	169	Mass-based	10 kg/day	4.2 kg/day

6.2.2. Dry-weather load allocations. Dry-weather nonpoint source mass-based load allocations for copper and lead are developed for open space and direct atmospheric deposition to the river. Most of the land area in the watershed is served by the storm drain system. The exception is the area of the Angeles National Forest and the open areas of the Santa Susana Mountains. Therefore, in equation 7, "open space" refers to opens space that discharges directly to the river and not through the storm drain system. Once drainage from "open space" is collected by the storm drain system it becomes a point source and is included with the storm water allocation. The area not served by the storm drain is approximately 200 square miles[1]. Limited data are available on flows from Aliso Canyon Wash, Browns Canyon and Bull Creek, which drain the Santa Susana Mountains. Dry-weather flow from the Santa Susana Mountains is therefore not included in the calculation of open space load allocations for copper and lead. Because their area is small compared to the National Forest and because there is no evidence of copper or lead impairments in Reach 6, it is reasonable to assume that the contribution from Santa Susana Mountains to downstream impairments in Reaches 5,4, 3, 2 and 1 is negligible. Therefore, for the purposes of calculating load allocations for copper and lead to address these impairments, open space is limited to the Angeles National Forest. Tributaries of the Rio Hondo, including Monrovia Canyon Creek, drain the Angeles Forest, but since their flows do not reach Rio Hondo Reach 1 or the mainstem of the Los Angeles River during dry weather, they are not included in the copper and lead load allocations. The two remaining major tributaries that drain the Angeles Forest are the Tujunga Wash and Arroyo Seco. In order to calculate the copper and lead load allocations for nonpoint sources in these tributaries, the median flow from the upper portion of each tributary, based on LACDPW flow records (1988-2000) is multiplied by the numeric targets (Table 3-2) for each reach. These load allocations are presented in Table 6-4.

Table 6.4. Dry-weather load allocations (total recoverable metals) for open space not served by the storm drain system, based on tributaries that drain the Angeles National Forest.

Tributaries	Open Space Critical Flow (cfs)	Copper (kg/day)	Lead (kg/day)
Tujunga Wash	0.12	0.0056	0.0028
Arroyo Seco	0.33	0.018	0.009
Total	0.45	0.023	0.012

[1] As determined by Regional Board staff through GIS mapping using City and County storm drain layers and U.S. Census information on populated areas.

Load allocations for direct atmospheric deposition are based on the calculations by Sabin et al., as discussed Section 4 (Table 4-6), and allocated to each reach based on the length of each reach and tributary (Table 6-5). The ratio of the length of each segment over the total length of all segments is multiplied by the estimates of direct atmospheric loading (3 kg/year for copper, 2 kg/year for lead and 10 kg/year for zinc.) Segment lengths are presented in the dry-weather model (Appendix I).

Table 6-5. Dry-weather load allocations (total recoverable metals) for direct atmospheric deposition.

Los Angeles River	Length of Reach (miles)	Copper (kg/day)	Lead (kg/day)	Zinc (kg/day)
LA River Reach 6	4.3	$3.3x10^{-4}$	$2.2x10^{-4}$	
LA River Reach 5	4.7	$3.6x10^{-4}$	$2.4x10^{-4}$	
LA River Reach 4	10.6	$8.1x10^{-4}$	$5.4x10^{-4}$	
LA River Reach 3	7.9	$6.04x10^{-4}$	$4.03x10^{-4}$	
LA River Reach 2	18.7	$1.4\ x10^{-3}$	$9.5x10^{-4}$	
LA River Reach 1	5.8	$4.4x10^{-4}$	$2.96x10^{-4}$	
Tributaries	**Length of Reach (miles)**	**Copper**	**Lead**	
Bell Creek	3.9	$2.98x10^{-4}$	$1.99x10^{-4}$	
Tujunga Wash	9.7	$7.4x10^{-4}$	$4.9x10^{-4}$	
Verdugo Wash	6.2	$4.7x10^{-4}$	$3.2x10^{-4}$	
Burbank Western Channel	9.3	$7.1x10^{-4}$	$4.7x10^{-4}$	
Arroyo Seco	9.6	$7.3x10^{-4}$	$4.9x10^{-4}$	
Rio Hondo Reach 1	8.3	$6.4x10^{-4}$	$4.2x10^{-4}$	0.0021
Compton Creek	8.5	$6.5x10^{-4}$	$4.3x10^{-4}$	
Total	107.5	0.0082	0.0055	0.0021

A concentration-based load allocation equal to 5 μg/L for selenium is assigned to Reach 6 and its tributaries. This load allocation is not assigned to a particular nonpoint source or group of nonpoint sources because the sources of selenium are uncertain. Separate studies are underway to evaluate whether selenium levels represent a natural condition for this watershed.

A concentration-based load allocation for lead equal to 8.2 μg/L (based on numeric targets in table 3-2) is also developed for lead in Monrovia Canyon Creek. The Monrovia Canyon Creek watershed is entirely open space, the majority of which is National Forest or State Park. This load allocation is not assigned to a particular nonpoint source or group of nonpoint sources because the sources of lead are uncertain. However, based on the open space land uses in this sub-watershed, the sources are likely natural or background sources. Because there is no flow information for Monrovia Canyon Creek, a concentration-based load allocation is developed. A study by SCCWRP is currently underway to quantify natural contributions of pollutants during wet and dry weather.

6.2.3 Dry-weather waste load allocations for storm water permittees. A dry-weather mass-based waste load allocation is developed for storm water permittees according to the following equation:

Storm Water = TMDL – POTW – Open Space - Direct Air Deposition **Equation (8)**

More specifically, the waste load allocation for storm water is calculated by multiplying reach specific critical flows attributable to storm drains (total critical flow minus median POTW flows minus median open space flows) by reach-specific numeric targets, then subtracting the contribution from direct air deposition, according to the following equation:

Storm Water = target * ($Flow_{Critical} - Flow_{median\ POTW} - Flow_{median\ Open}$) - Direct Air Deposition **Equation (9)**

For accounting purposes, it is assumed that the Caltrans and general storm water permittees discharge entirely to the MS4 system. This assumption has largely been borne out in out permit review. A zero waste load allocation is assigned to all industrial and construction stormwater permits during dry weather. Order Nos. 97-03 DWQ and 99-08 DWQ already prohibit non-storm water discharges with few exceptions as discussed in Section 4.1.2. The remaining waste load allocation (Table 6-6) is shared by the MS4 permittees and Caltrans. It is not possible to divide this allocation between the MS4 and Caltrans permittees because there is not enough data on the relative reach-specific extent of MS4 and Caltrans areas.

Table 6-6. Dry-weather waste allocations for storm water permittees (expressed as total recoverable metals)

Los Angeles River	Critical Flow (cfs)	Copper (kg/day)	Lead (kg/day)	Zinc (kg/day)
LA River Reach 6	7.20	0.53	0.33	
LA River Reach 5	0.75	0.05	0.03	
LA River Reach 4	5.13	0.32	0.12	
LA River Reach 3	4.84	0.06	0.03	
LA River Reach 2	3.86	0.13	0.07	
LA River Reach 1	2.58	0.14	0.07	
Tributaries	**Critical Flow**	**Copper**	**Lead**	**Zinc**
Bell Creek	0.79	0.06	0.04	
Tujunga Wash	0.03	0.001	0.0002	
Verdugo Wash	3.3	0.15	0.07	
Burbank Western Channel	3.30	0.18	0.10	
Arroyo Seco	0.25	0.01	0.01	
Rio Hondo Reach 1	0.50	0.01	0.006	0.16
Compton Creek	0.90	0.04	0.02	
Total	34	1.70	0.89	0.16

6.2.4. Dry-weather waste load allocations for other NPDES permits.

Concentration-based waste load allocations are developed for the minor and general (non-storm water) NPDES dischargers that discharge to the reaches in Table 3-2. Concentration-based waste load allocations are also assigned to the Tapia and Whittier Narrows WRPs, which have low infrequent flows. The permitted flow from Tapia is less than 2% of the mean flow from Tillman WRP, Burbank WRP and Glendale WRP. Concentration-based waste load allocations are also assigned to the three major non-POTW permits. These permits are for intermittent discharges of storm water runoff mixed with industrial wastewater and miscellaneous designated waste and it is not possible to assign them a mass-based allocation. If waste load allocations were assigned to intermittent discharges based on the maximum permitted daily flow, collectively their loads combined with the POTW loads would exceed the TMDL for the river, leaving no allocation for the storm water permittees. By providing concentration-based limits, we ensure that the loads from intermittent discharges are associated with an increased assimilative capacity such that water quality standards will be attained. Concentration-based waste load allocations are equal to the dry-weather numeric targets, expressed as total recoverable metals, provided in Table 3-2.

The Los Angeles Zoo wastewater facility discharges only in wet weather when capacity of the retention basin is exceeded. It is assigned a dry-weather waste load allocation equal to zero.

6.3. Wet-Weather Loading Capacity (Load-Duration Curves) and TMDLs

During wet weather, the allowable load is a function of the volume of water in the river. Given the variability in wet-weather flows, the concept of a single critical flow is not justified. Instead, a load-duration curve approach is used to establish the wet-weather loading capacity. In brief, a load-duration curve is developed by multiplying the wet-weather flows by the in-stream numeric target. The result is a curve which identifies the allowable load for a given flow. Table 6-7 presents the equations used to calculate the load duration curves. The wet-weather TMDLs for metals are defined by these load-duration curves. The wet-weather loading TMDLs apply for days when the maximum flow at Wardlow equals or exceeds 500 cfs, which represents the 90th percentile flow.

Table 6-7. Wet-weather loading capacity (TMDLs) for metals expressed in terms of total recoverable metal

Metal	Load Duration Curve
Cadmium	Daily storm volume x 3.1 μg/L
Copper	Daily storm volume x 17 μg/L
Lead	Daily storm volume x 62 μg/L
Zinc	Daily storm volume x 159 μg/L

An example of a load duration curve is presented in Figure 11. This example is generated by multiplying the wet-weather numeric target for copper by daily storm volumes generated by the wet-weather model for a 12-year period. A daily flow of 500 cfs (daily storm volume = $1.2x10^9$ liters) results in the loading capacities presented in Table 6-8. For practical purposes the wet-weather loading capacity defined using the load-duration curve is equivalent to a storm water event-mean concentration based on a flow weighted composite.

Table 6-8. Loading capacity based on a daily flow equal to 500 cfs.

Metal	Loading Capacity (kg/day)
Cadmium	3.8
Copper	21
Lead	76
Zinc	194

6.4 Wet-Weather Allocations

Wet-weather allocations are assigned in the same way as dry-weather allocations (Equation 7), except that there are no reach specific allocations. Wet-weather allocations apply to all reaches and tributraies of the Los Angeles River. With the exception of the Tillman, Glendale, and Burbank WRPs, wet-weather allocations are based on flows and hardness values for the Wardlow station in Reach 1.

6.4.1. Wet-weather waste load allocations for three POTWs. Wet-weather allocations are based on dry-weather in-stream numeric targets because the POTWs exert the greatest influence over in-stream water quality during dry weather, and collectively they contribute minimally to the total wet-weather loading. During wet weather, the concentration-based dry-weather waste load allocations apply but the mass-based dry-weather allocations do not apply when influent flows exceed the design capacity of the treatment plants. In addition to the waste load allocations for copper and lead in dry weather, the POTWs are assigned reach-specific allocations for cadmium and zinc based on dry-weather targets to meet the wet-weather TMDLs in Reach 1 (Table 6-9).

Table 6-9. Wet-weather waste load allocations for three POTWs (expressed as total recoverable metals)

Facility	Design Flow (cfs)	WLA	Cadmium	Copper	Lead	Zinc
Tillman	124	Concentration-based	4.7 μg/L	26 μg/L	10 μg/L	212 μg/L
		Mass-based	1.4 kg/day	7.8 kg/day	3.03 kg/day	64 kg/day
Glendale	31	Concentration-based	5.3 μg/L	26 μg/L	12 μg/L	253 μg/L
		Mass-based	0.40 kg/day	2.0 kg/day	0.88 kg/day	19 kg/day
Burbank	14	Concentration-based	4.5 μg/L	19 μg/L	9.1 μg/L	212 μg/L
		Mass-based	0.15 kg/day	0.64 kg/day	0.31 kg/day	7.3 kg/day
Total	169	Mass-based	1.95 kg/day	10 kg/day	4.2 kg/day	90 kg/day

6.4.2. Wet-weather load allocations.

Wet-weather Load Allocations for Open Space

As with the calculation of dry-weather allocations, wet-weather load allocations are only assigned to open space that discharges directly to the river. In order to assign load allocations to open space, the model-predicted percent contribution from open space is multiplied by the total loading capacity, or TMDL. This product is then multiplied by the ratio of open space located outside the storm drain system (see section 6.2.2) to the total open space area ($200\ mi^2/368mi^2 = 0.54$), according to the following equation:

Open Space = % Open Space Contribution * TMDL* 0.54 **Equation (10)**

Based on the wet-weather model (Appendix II) open space contributes 2.8% of the copper load, 0.7% of the lead load and 1.6% of the zinc load. The model tends to overestimate loads, which provides a conservative assessment of the contribution from open space and can be applied to the margin of safety. The wet-weather model does not estimate contributions from cadmium, but there is little evidence to suggest undeveloped areas as a potential source of cadmium. The wet-weather cadmium impairment could only be confirmed in Reach 1. There is no evidence of impairment in Reaches 3, 4, 5, and 6, or tributaries where there is open space. Therefore, no load allocation is developed for cadmium.

Wet-weather Load Allocations for Direct Air Deposition

An estimate of direct atmospheric deposition is developed based on the percent area of surface water, which is about 0.2% of the total watershed area (Table 5-4). The load allocation for atmospheric deposition is calculated by multiplying this percentage by the total loading capacity, according to the following equation:

Direct Air Deposition = 0.002 * TMDL **Equation (11)**

The loadings associated with indirect deposition are included in the wet-weather storm water waste load allocations.

As with the dry-weather condition, a concentration-based wet-weather WLA equal to 5 µg/L for selenium has been assigned to Reach 6 and its tributaries.

6.4.3. Wet-weather waste load allocations for storm water permittees. Wet-weather waste load allocations are calculated by combining equations 8, 10, and 11, resulting in the following equation:

Storm Water = (1– 0.002 - %Open Space Contribution*0.54)*TMDL–POTW **Equation (12)**

Wet-weather allocations for POTWs, open space, direct air deposition and storm water are presented in Table 6-10.

Table 6.10. Wet-weather allocations for open space, direct air, POTWs and storm water.

	Open Space (kg/day)	Direct Air (kg/day)	Burbank WRP (kg/day)	Tillman WRP (kg/day)	LAG WRP (kg/day)	Storm water permittees (kg/day)
Cadmium		6.2×10^{-12} * daily volume (L)	0.15	1.4	0.40	3.1×10^{-9}*daily volume(L) – 1.95
Copper	2.6×10^{-10} * daily volume (L)	3.4×10^{-11} * daily volume (L)	0.64	7.8	1.99	1.7×10^{-8}*daily volume (L) – 10.4
Lead	2.4×10^{-10} * daily volume (L)	1.2×10^{-10} * daily volume (L)	0.31	3.03	0.88	6.2×10^{-8}*daily volume (L) – 4.2
Zinc	1.4×10^{-9} * daily volume (L)	3.2×10^{-10} * daily volume (L)	7.3	64	19	1.6×10^{-7}*daily volume (L) – 90

L = Liters

For example, a daily flow of 500 cfs (daily storm volume = 1.2×10^{9} liters) results in the allocations presented in Table 6-11.

Table 6-11. Wet-weather allocations based on a daily flow equal to 500 cfs.

	Open Space (kg/day)	Direct Air (kg/day)	Burbank WRP (kg/day)	Tillman WRP (kg/day)	LAG WRP (kg/day)	Storm water permittees (kg/day)
Cadmium		0.0074	0.15	1.4	0.4	1.8
Copper	0.31	0.041	0.64	7.8	1.9	10
Lead	0.29	0.14	0.31	3.03	0.88	71
Zinc	1.7	0.38	7.3	64	19	102

EPA allows allocations for NPDES-regulated municipal storm water discharges from multiple point sources to be expressed as a single categorical waste load allocation when data and information are insufficient to assign each source or outfall an individual allocation. We recognize that these municipal storm water allocations may be fairly rudimentary because of data limitations and variability in the system. The combined storm water waste load allocation is apportioned between the different storm water categories based on acreage. For the Los Angeles River watershed, the total acreage for each category is:

- Combined stormwater permittees: 405,760 acres. This is equal to the total watershed area minus the open space area not covered by storm drains.
- Caltrans: 6950 acres or 2% of the portion of the watershed served by storm drains. This is an approximation that reflects the area of the Department's Right-of-Way that drains to Los Angeles River (Caltrans comment letter dated 8/26/04.)
- Industrial: 21,415 acres or 5% of the portion of the watershed served by storm drains. Total acreage was obtained from State Board enrollment database.
- Construction: 7764 acres or 2% of the portion of the watershed served by storm drains. Total acreage was obtained from State Board enrollment database.
- Remaining allocated to the MS4: 369,631 acres or 91% of the portion of the watershed served by strom drains.

Based on these areas, the waste load allocations estimated for each permit type are presented in Table 6-12.

Table 6.12. Wet-weather combined storm water allocations, apportioned based on percent of total urbanized portion of watershed.

	General Industrial permittees (kg/day)	General Construction permittees (kg/day)	Caltrans (kg/day)	MS4 Permittees (kg/day)	Combined storm water permittees (kg/day)
Cadmium	1.6E-10*daily volume(L) – 0.11	5.9E-11*daily volume(L) – 0.04	5.3E-11*daily volume(L) – 0.03	2.8E-09*daily volume(L) – 1.82	3.1E-09*daily volume(L) – 1.95
Copper	8.8E-10*daily volume (L) – 0.5	3.2E-10*daily volume (L) – 0.2	2.9E-10*daily volume (L) – 0.2	1.5E-08*daily volume (L) – 9.5	1.7E-08*daily volume (L) – 10
Lead	3.3E-09*daily volume (L) – 0.22	1.2E-09*daily volume (L) – 0.08	1.06E-09*daily volume (L) – 0.07	5.6E-08*daily volume (L) – 3.85	6.2E-08*daily volume (L) – 4.2
Zinc	8.3E-09*daily volume (L) – 4.8	3.01E-09*daily volume (L) – 4.8	2.7E-09*daily volume (L) – 1.6	1.4E-07*daily volume (L) – 83	1.6-07*daily volume (L) – 90

For example, a daily flow of 500 cfs (daily storm volume = 1.2×10^9 liters) results in the storm water waste load allocations presented in Table 6-13.

Table 6-13. Wet-weather waste load allocations for storm water based on a daily flow of 500 cfs.

	General Industrial permittees (kg/day)	General Construction permittees (kg/day)	Caltrans (kg/day)	MS4 Permittees (kg/day)	Combined storm water permittees (kg/day)
Cadmium	0.089	0.036	0.036	1.6	1.8
Copper	0.50	0.20	0.20	9.1	10
Lead	3.6	1.4	1.4	65	71
Zinc	5.08	2.03	2.03	93	102

Each storm water permittee under the general industrial and construction storm water permits will receive an individual waste load allocations per acre based on the total acres of their facility. This results in the same per acre allocation for the industrial and construction storm water permittees (Table 6-14).

Table 6-14. Wet-weather waste load allocations for individual general construction or industrial storm water permittees (kg/day/acre).

Metal	Individual General Construction or Industrial Permittee (g/day/acre)
Cadmium	7.6×10^{-12} * daily storm volume (L) – 4.8×10^{-6}
Copper	4.2×10^{-11} * daily storm volume (L) – 2.6×10^{-5}
Lead	1.5×10^{-10} * daily storm volume (L) -1.04×10^{-5}
Zinc	3.9×10^{-10} * daily storm volume (L) – 2.2×10^{-4}

For example, a daily flow of 500 cfs (daily storm volume = 1.2×10^9 liters) results in the general construction and industrial storm water waste load allocations presented in Table 6-15.

Table 6-15. We-weather waste load allocations for individual general construction or industrial storm water permittees (g/day/acre) based on a daily flow equal to 500 cfs.

Metal	Individual General Construction Permittee (g/day/acre)
Cadmium	0.0044
Copper	0.026
Lead	0.18
Zinc	0.26

6.4.4. Wet-weather waste load allocations for other NPDES permits. Concentration-based WLAs are established for the minor and general NPDES permits (other than storm water permittees) that discharge to the Los Angeles River and its tributaries to ensure that these do not contribute significant loadings to the system. This was done because the flows are so variable that a representative collective flow and loading cannot be calculated. Concentration-based waste load allocations are also assigned to the Los Angeles Zoo wastewater facility and the Tapia and Whittier Narrows WRPs, which have low infrequent flows. The zoo facility discharges only during wet-weather and only when capacity of the 1.8 million-gallon retention basin is exceeded. The permitted flow from Tapia is less than 2% of the mean flow from Tillman WRP, Burbank WRP and Glendale WRP. It is estimated that less than 1% of the flow from Whittier Narrows WRP leaves the spreading grounds and enters the Rio Hondo. Concentration-based allocations are also assigned to the three non-POTW major NPDES permits because their discharges are a mixture of intermittent storm water and wastewater. The concentration-based WLAs are based on CTR targets adjusted for hardness and expressed as total recoverable metals. (Table 6-16.)

Table 6-16. Concentration-based wet -weather waste load allocations (µg/L total recoverable metals).

Cadmium	Copper	Lead	Zinc
3.1	17	62	159

6.5 Margin of Safety

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationships between effluent limitations and water quality. A margin of safety is appropriate for each TMDL because there is significant uncertainty in the analysis of pollutant loads and effects on water quality. There is an implicit margin of safety that stems from the use of conservative values for the conversion total recoverable to the dissolved fraction during the dry and wet periods. In addition, the TMDL includes a margin of safety by evaluating wet-weather conditions separately from dry-weather conditions, which is in effect, assigning allocations for two distinct critical conditions. Furthermore, the use of the wet-weather model to calculate load allocations for open space can be applied to the margin of safety because it tends to overestimate loads from open space, thus reducing the available waste load allocations to the permitted discharges.

7. IMPLEMENTATION

In this section, we describe the implementation procedures that will be used to provide reasonable assurances that water quality standards will be met. Further, the reasonably foreseeable means of compliance with the TMDL are discussed.

Nonpoint sources will be regulated through the authority contained in sections 13263 and 13269 of the Water Code, in conformance with the State Water Resources Control Board's Nonpoint Source Implementation and Enforcement Policy (May 2004).

The mass- and concentration-based WLAs established for the three major POTWs in this TMDL will be implemented through NPDES permit limits. The renewal of the NPDES permits for the three major POTWs is tentatively scheduled for July 2005. The three POTWs will have permit limits designed to meet the water quality targets established in this TMDL and maintain water quality standards in the Los Angeles River. These limits take into account the variability in the effluent data and the frequency of monitoring. During wet weather when the inflow to the treatment plants exceeds the design capacity, the mass-based limit will not apply.

If a POTW determines that advanced treatment (necessitating long design and construction timeframes) will be required to meet final waste load allocations, the Regional Board will consider extending the implementation schedule to allow the POTW up to 10 years from the effective date of the TMDL. POTWs that are unable to demonstrate compliance with final waste load allocations must conduct source reduction audits within two years of the effective date of the TMDL. POTWs that will be requesting the Regional Board to extend their implementation schedule to allow for the installation of advanced treatment must prepare work plans, with time schedules to allow for the installation of advanced treatment. The work plan must be submitted within four years from the effective date of the TMDL. POTWs that require advanced treatment to meet waste load allocations would be required to conduct a separate project level analysis of potential environmental impacts associated with installation and operation of advanced treatment (Public Resources Code 21159.2).

The concentration-based waste load allocations for minor NPDES discharges, NPDES discharges covered under a general permit and major NPDES discharges excluding the Tillman, LA-Glendale, and Burbank POTWs will be implemented through NPDES permit limits. Reach-specific dry-weather waste load allocations are equal to the numeric targets in Table 3-2 and wet-weather waste load allocations are described in Table 6-12. Permit writers for the non-storm water permits may translate waste load allocations into effluent limits by applying the SIP procedures or other applicable engineering practices authorized under federal regulations. Compliance schedules may be established in individual NPDES permits, allowing up to 5 years within a permit cycle to achieve compliance. Compliance schedules may not be established in general NPDES permits. A discharger that could not comply immediately with effluent limitations specified to implement waste load allocations would be required to apply for an individual permit in order to demonstrate the need for a compliance schedule. Permittees that hold individual NPDES permits and solely discharge storm water may be allowed (at Regional

Board discretion) compliance schedules up to 10 years from the effective date of the TMDL to achieve compliance with final WLAs.

Non-storm water flows authorized by Order No. 97-03 DWQ, or any successor order, are exempt from the dry-weather waste load allocation equal to zero. Instead, these authorized non-storm water flows shall meet the reach-specific concentration-based waste load allocations assigned to the "other NPDES permits" in Table 3-2. The dry-weather waste load allocation equal to zero applies to unauthorized non-storm water flows, which are prohibited by Order No. 97-03 DWQ. It is anticipated that the dry-weather waste load allocations will be implemented in future general permits through the requirement of improved BMPs to eliminate the discharge of non-storm water flows.

The wet-weather mass-based waste load allocations for the general industrial storm water permittees (Table 6-15) will be incorporated into watershed specific general permits. Concentration-based permit conditions may be set to achieve the mass-based waste load allocations. These concentration-based conditions would be equal to the concentration-based waste load allocations assigned to the other NPDES permits (Table 6-16). Compliance with permit conditions may be demonstrated through the installation, maintenance, and monitoring of Regional Board-approved BMPs. If this method of compliance is chosen, permit writers must provide adequate justification and documentation to demonstrate that specified BMPs are expected to result in attainment of the numeric waste load allocations.

General industrial storm water permittees are allowed interim concentration-based wet-weather waste load allocations based on benchmarks contained in EPA's Storm Water Multi-sector General Permit for Industrial Activities. The interim waste load allocations apply to all industry sectors and will apply for a period not to exceed ten years from the effective date of the TMDL.

Table 7-1. Interim wet- weather WLAs for general industrial storm water permittees, expressed as total recoverable metals (µg/L)*:

Cadmium	Copper	Lead	Zinc
15.9	63.6	81.6	117

*Based on USEPA benchmarks for industrial storm water sector

In the first five years from the effective date of the TMDL, interim wet-weather waste load allocations will not be interpreted as enforceable permit conditions. If monitoring demonstrates that interim waste load allocations are being exceeded, the permittee shall evaluate existing and potential BMPs, including structural BMPs, and implement any necessary BMP improvements. It is anticipated that monitoring results and any necessary BMP improvements would occur as part of an annual reporting process. After five years from the effective date of the TMDL, interim waste load allocations shall be translated into enforceable permit conditions. Compliance with conditions may be demonstrated through the installation, maintenance, and monitoring of Regional Board-approved BMPs. Permit writers must provide adequate justification and documentation to demonstrate that specified BMPs are expected to result in attainment of waste load allocations. In addition, permittees shall begin an iterative BMP process to meet final waste load allocations. Permittees shall comply with final waste load allocations within 10 years from the effective date of the TMDL, which shall be expressed as water quality based effluent limitations. Effluent limitations may be expressed as permit conditions. Compliance with conditions may be demonstrated through the installation, maintenance, and monitoring of Regional Board-approved BMPs. Permit writers must provide adequate justification and documentation to demonstrate that specified BMPs are expected to result in attainment of waste load allocations.

Waste load allocations for the general construction storm water permits will be incorporated into the State Board general permit upon renewal or into a watershed-specific general permit developed by the Regional Board. Non-storm water flows authorized by the General Permit for Storm Water Discharges Associated with Construction Activity (Water Quality Order No. 99-08 DWQ), or any successor order, are exempt from the dry-weather waste load allocation equal to zero as long as they comply with the provisions of sections C.3.and A.9 of the Order No. 99-08 DWQ, which state that these authorized non-storm discharges shall be (1) infeasible to eliminate (2) comply with BMPs as described in the Storm Water Pollution Prevention Plan prepared by the permittee, and (3) not cause or contribute to a violation of water quality standards, or comparable provisions in any successor order. Unauthorized non-storm water flows are already prohibited by Order No. 99-08 DWQ.

Within seven years of the effective date of the TMDL, the construction industry will submit the results of BMP effectiveness studies to determine BMPs that will achieve compliance with the final waste load allocations assigned to construction storm water permittees. Regional Board staff will bring the recommended BMPs before the Regional Board for consideration within eight years of the effective date of the TMDL. General construction storm water permittees will be considered in compliance with final waste load allocations if they implement these Regional Board approved BMPs. All permittees must implement the approved BMPs within nine years of the effective date of the TMDL. If no effectiveness studies are conducted and no BMPs are approved by the Regional Board within eight years of the effective date of the TMDL, each general construction storm water permit holder will be subject to site-specific BMPs and monitoring requirements to demonstrate compliance with final waste load allocations.

A grouped dry-weather and wet-weather mass-based waste load allocation has been developed for the two MS4 permits and the Caltrans permit (Tables 6-6 and 6-10). EPA regulation allows allocations for NPDES-regulated stormwater discharges from multiple point sources to be expressed as a single categorical waste load allocation when the data and information are insufficient to assign each source or outfall individual WLAs. The grouped allocation will apply to all NPDES-regulated municipal stormwater discharges in the Los Angeles watershed including the Los Angeles County MS4 permit, the City of Long Beach MS4 permit, and the Caltrans stormwater permit. The watershed is divided into six subwatersheds, with jurisdictional groups assigned to each subwatershed, as presented in Table 7-2. Jurisdictional groups can be reprganized or subdivided upon approval by the Executive Offcier.

Table 7-2. Los Angeles River and Tributaries Metals TMDL: Jurisdictional Groups

Jurisdictional Group	Responsible Jurisdictions & Agencies		Subwatershed(s)
1	Carson County of Los Angeles City of Los Angeles Compton Huntington Park	Long Beach Lynwood Signal Hill Southgate Vernon	Los Angeles River Reach 1 and Compton Creek
2	Alhambra Altadena Arcadia Bell Bell Gardens Bellflower Bradbury Carson Commerce Compton County of Los Angeles Cudahy Downey Duarte El Monte Glendale Glendale Huntington Park Irwindale La Canada Flintridge	Lakewood City of Los Angeles Long Beach Lynwood Maywood Monrovia Montebello Monterey Park Paramount Pasadena Pico Rivera Rosemead San Gabriel San Marino Sierra Madre South El Monte South Pasadena Southgate Temple City Vernon	Los Angeles River Reach 2, Rio Hondo, Arroyo Seco, and all contributing sub watersheds
3	City of Los Angeles County of Los Angeles Burbank Glendale La Canada Flintridge Pasadena		Los Angeles River Reach 3, Verdugo Wash, Burbank Western Channel
4-5	Burbank City of Los Angeles County of Los Angeles Glendale San Fernando		Los Angeles River Reach 4, Reach 5, Tujunga Wash, and all contributing sub watersheds
6	Calabasas City of Los Angeles County of Los Angeles Hidden Hills		Los Angeles River Reach 6, Bell Creek, and all contributing sub watersheds

EPA policy requires that the waste load allocations for stormwater be expressed in numeric form. For the dry-weather condition, mass-based waste load allocations (Table 6-6) will be incorporated into the permits of the NPDES-regulated municipal stormwater discharges. A review of available water quality data suggests that applicable CTR limits are being met most of the time during dry weather, with episodic exceedances. Due to the expense of obtaining accurate flow measurements required for calculating loads, concentration-based permit limits may apply during dry weather. These concentration-based limits would be equal to the dry-weather reach-specific numeric targets (Table 3-2). Dry-weather waste load allocations apply to each jurisdictional group based on the subwatershed(s) defining the group. For example, the dry-weather waste load allocations for Compton Creek and Reach 1 apply to responsible agencies within Jurisdictional Group 1. For wet weather, the municipal stormwater waste load allocations are presented in Table 6-10. These may be allocated to each jurisdictional group.

Each municipality and permittee will be responsible for the waste load allocations shared by their jurisdictional group, and will not necessarily be given a specific allocation for the land uses under their jurisdiction. Therefore, the focus of compliance should be on developed areas where the contribution of metals is highest and areas where activities occur that contribute significant loading of metals (e.g., high-density residential, industrial areas and highways). Flexibility will be allowed in determining how to reduce metals as long as the waste load allocations are achieved. The information provided in Table 7-3 should help MS4 and Caltrans stormwater permittees identify areas of high pollutant loading and may be used to target BMPs. In this table, many of the land use categories that share hydrologic or pollutant loading characteristics are grouped into similar classifications. For example, transportation is grouped with the industrial land use since the potency factors used in the wet-weather modeling (section 5.2) were very similar.

Table 7-3. Land use contributions to total metal loads from surface runoff from the Los Angeles River watershed. Based on wet-weather model predictions (Appendix II)

Land Use	Copper	Lead	Zinc
Agriculture	0.5%	0.2%	0.5%
Commercial	13.4%	18.6%	18.2%
Industrial	11.2%	9.1%	19.9%
Mixed Urban	0.7%	0.3%	0.6%
Residential	71.5%	71.1%	59.3%
Open Space	2.8%	0.7%	1.6%

To achieve the necessary reductions to meet the waste load allocations, permittees will need to balance short-term capital investments directed to addressing this and other TMDLs in the Los Angeles River watershed with long-term planning activities for stormwater management in the region as a whole. It should be emphasized that the potential implementation strategies discussed below may contribute to the implementation of other TMDLs for the Los Angeles River watershed. Likewise, implementation of other TMDLs in the Los Angeles River watershed may contribute to the implementation of this TMDL. The Los Angeles River Trash TMDL, effective date August 2, 2002, is now in its first year of implementation. Compliance with the Trash TMDL requires permittees to install either full capture systems, partial capture systems and/or implement institutional controls. At a minimum, the full capture systems must be designed to treat the peak flow rate resulting from a one-year, one-hour storm. A secondary benefit of the trash removal systems also referred to as gross solids removal systems has been the removal of sediments and other pollutants.

Figures 12 a-12c present the estimated load reductions needed to meet the grouped storm water waste load allocations. In these figures, allowable loads are plotted against storm volume to assist permittees in the design of BMPs to achieve the necessary load reductions. As described in section 5.2, The LSPC model was used to simulate storm volumes and associated loads over a 12-year period. For these figures, the loading capacity is a green line, the model-predicted historical loads below the loading capacity are shaded with blue and the model-predicted historical loads above the loading capacity are shaded with red. Because the model tends to overestimate loads, actual reductions needed to meet the waste load allocations are likely less than predicted by the load-duration curves. Wet-weather historical loadings for cadmium were not modeled in this TMDL. A data review (section 2.2) provided little evidence of wet-weather exceedances for cadmium and estimates of wet-weather loadings of cadmium (LACDPW, 2000 and Ackerman and Schiff, 2003) were well below the allowable load.

7.1 Integrated Resources Plan

The Regional Board supports in concept an integrated water resources approach to improving water quality during wet weather, such as the City of Los Angeles' Integrated Plan for the Wastewater Program (IPWP). An integrated water resources approach takes a holistic view of regional water resources management by integrating planning for future wastewater, stormwater, recycled water, and potable water needs and systems, and focusing on beneficial re-use of stormwater at multiple points throughout a watershed to preserve local groundwater resources and reduce the need for imported water where feasible. The City's IPWP is intended to meet the wastewater and water resource management needs for year 2020.

The Integrated Resources Plan (IRP) is Phase 2 of the IPWP. The IRP is a City-wide strategy developed by the City of Los Angeles and does not specifically focus on the Los Angeles River watershed. The goal of the plan is to increase the amount of wet weather urban runoff that can be captured and beneficially used in Los Angeles. However, it is not known what portion of this runoff will be in the Los Angeles River Watershed. Furthermore, capture and beneficial use of the wet-weather urban runoff specified in the IRP may not achieve the waste load allocations in this TMDL during very wet years. The implementation strategy proposed below could be designed to achieve the TMDL requirements, while remaining consistent with the goals of the City's IPWP and addressing any shortfall of the IRP in achieving implementation with this TMDL.

One component of the IRP is a Runoff Management Plan, which could provide a framework for implementing runoff management practices to meet the IRP goals and address protection of public health and the environment. The Runoff Management Plan as described in the IRP will include consideration of structural Best Management Practices (BMPs) to achieve reduction of pollutant loadings to receiving waters. Urban runoff can be treated at strategic locations throughout the watershed or subwatersheds.

7.2 Potential Implementation Strategies for MS4 and Caltrans Permits

The implementation strategy selected will need to address the different sources of metals loading during dry and wet weather. During dry weather, metals loading are predominately in the dissolved phase. During wet weather, the metals loading are predominately bound to sediment, which are transported with storm runoff. During rain events, partitioning between particulate and dissolved metals often does not reach equilibrium. Municipalities may employ a variety of implementation strategies to meet the required WLAs such as non-structural and structural BMPs, and/or diversion and treatment. Specific projects, which may have a significant environmental impact, would be subject to an environmental review. The lead agency for subsequent projects would be obligated to mitigate any impacts they identify, for example by mitigating potential flooding impacts by designing the BMPs with adequate margins of safety.

7.2.1 Non-structural BMPs. The non-structural BMPs are based on the premise that specific land uses or critical sources can be targeted to achieve the TMDL waste load allocations. Non-structural BMPs provide several advantages over structural BMPs. Non-structural BMPs can typically be implemented in a relatively short period of time. The capital investment required to implement non-structural BMPs is generally less than for structural BMPs. However, the labor costs associated with non-structural BMPs may be higher. Therefore, in the long-term, the non-structural BMPs may be more costly. Examples of non-structural controls include more frequent and appropriately timed storm drain catch basin cleanings, improved street cleaning by upgrading to vacuum type sweepers and educating industries of good housekeeping practices. Since dry-weather exceedances appear to be episodic, the permittees are encouraged to initially concentrate on source reduction strategies including detection and elimination of illicit discharges, reduction of dry-weather nuisance flows, and increased inspection of industrial facilities. In addition, improved enforcement of BMPs for construction sites and improved detection and elimination of illicit connections to the storm drain system may result in significant reductions in discharges of metal pollutants to the Los Angeles River.

A known source of copper loading is from brake pads. The use of alternative materials for brake pads would help to reduce the discharge of copper in all watersheds. Staff acknowledges the Brake Pad Partnership, a multistakeholder effort in the San Francisco Bay to understand and address as necessary the impacts on surface water quality that may arise from break pad wear debris.

7.2.2 Structural BMPs. The structural BMPs are based on the premise that specific land uses, critical sources, or specific periods of a storm event can be targeted to achieve the TMDL waste load allocations. Structural BMPs may include placement of stormwater treatment devices specifically designed to reduce metals loading, such as infiltration trenches or filters, at critical points in the stormwater conveyance system. During storm events, when flow rates are high, these types of filters may require surge control, such as an underground storage vault or detention basin. If these filters are placed in series with the gross solids removal systems being installed to meet the Trash TMDL, then these filters will operate more efficiently and will require less maintenance.

7.2.3 Diversion and Treatment. The diversion and treatment strategy includes the installation of facilities to provide capture and storage of dry and/or wet-weather runoff and diversion of the stored runoff to a wastewater collection system for treatment. A small, dedicated runoff treatment facility or alternative BMPs may be implemented to meet the TMDL requirements.

The volume of flow requiring storage and treatment would have to be estimated in order to size the storage facilities, estimate diversion flow rates, and determine the collection system and treatment capacities needed to accommodate these diverted flows. Wet-weather flows beyond the capacities of these facilities will be bypassed. However, a portion of these larger storm events will still be captured and treated, thereby eliminating the metals loading of small storms and reducing those of larger storms. Overflows from these systems could be routed through structural BMPs designed to remove sediment for further reduction of metal loads.

To assist responsible jurisdictions and agencies in determining the optimal volume of flow to be diverted, analyses were performed to assess relative improvements and benefits associated with capture of storm volumes. The capture of storm volumes reduces the associated metals loads, and therefore reduces the likelihood of exceedances of loading capacities of the receiving waters. These analyses were based primarily on conceptual assumptions and analyses of model results for guidance in future planning. To begin quantifying loading reductions, the results of the wet-weather model were re-analyzed with respect to size of storm flow. This was done by first developing a relationship between rainfall and storm volume for storms greater than 0.1 inch (Figure 13). We then used the regression to assess the effect of storm capture to reduce the associated metals loads, and therefore number of exceedances. The model suggests that the number of instances where model-predicted historical loads exceed the loading capacity can be halved through the capture of a 0.5 inch storm. These results are provided as guidance only and are not meant to imply that structural means are either necessary or adequate to meet the load reductions in this TMDL. Indeed, we believe that BMPs that result in source reductions rather than in-stream storm load reductions should be encouraged.

Additional studies that evaluate the effect of short duration rainfall intensity (i.e., one-year, one-hour rainfall event) on the mobilization and transport of metals are encouraged and would be useful in designing the flow through design capacity of in-line BMPs.

The administrative record and the fact sheets for the Los Angeles MS4 permit, the Long Beach MS4 permit, and the Caltrans stormwater permit must provide reasonable assurance that the BMPs selected will be sufficient to implement the waste load allocations in the TMDL. We expect that reductions to be achieved by each BMP will be documented and that sufficient monitoring be put in place to verify that the desired reductions are achieved. The permits should also provide a mechanism to make adjustments to the required BMPs as necessary to ensure their adequate performance. If non-structural BMPs alone adequately implement the waste load allocations then additional controls are not necessary. Alternatively, if the non-structural BMPs selected prove to be inadequate then structural BMPs or additional controls may be imposed.

7.3 Implementation Schedule

The implementation schedule for all permis is summarized in Table 7-4. For the MS4 and Caltrans storm water permittees, the implementation schedule shall consist of a phased approach. Each jurisdictional group shall achieve compliance in prescribed percentages of its subwatershed, with total compliance to be achieved within 22 years. The dry-weather compliance schedule is more accelerated because the dry-weather exceedances occur infrequently and major structural BMPs are not anticipated. The MS4 and Caltrans storm water permittees are encouraged to work together to identify areas to be addressed first.

The Regional Board intends to reconsider this TMDL in five years after the effective date of the TMDL to re-evaluate the waste load allocations based on the additional data obtained from special studies. Until the TMDL is revised, the waste load allocations will remain as presented in this report. Revising the TMDL will not create a conflict, since full compliance with the dry-weather WLAs and wet-weather WLAs are not required until 18 and 22-years after the effective date, respectively.

Table 7-4. Implementation Schedule.

Date	Action
Effective date of TMDL	Regional Board permit writers shall incorporate waste load allocations into NPDES permits. Waste load allocations will be implemented through NPDES permit limits in accordance with the implementation schedule contained herein, at the time of permit issuance, renewal, or re-opener.
4 years after effective date of the TMDL	Responsible jurisdictions and agencies shall provide to the Regional Board results of the special studies. POTWs that will be requesting the Regional Board to extend their implementation schedule to allow for the installation of advanced treatment must submit work plans.
5 years after effective date of the TMDLs	The Regional Board shall reconsider this TMDL to re-evaluate the waste load allocations and the implementation schedule.
NON-STORM WATER NPDES PERMITS (INCLUDING POTWS, OTHER MAJOR, MINOR, AND GENERAL PERMITS)	
Upon permit issuance, renewal, or re-opener	The non-storm water NPDES permits shall achieve waste load allocations, which shall be expressed as NPDES water quality-based effluent limitations specified in accordance with federal regulations and state policy on water quality control. . Compliance schedules may allow up to 5 years in individual NPDES permits to meet permit requirements. Compliance schedules may not be established in general NPDES permits. If a POTW demonstrates that advanced treatment will be required to meet final waste load allocations, the Regional Board will consider extending the implementation schedule to allow the POTW up to 10 years from the effective date of the TMDL to achieve compliance with the final WLAs. Permittees that hold individual NPDES permits and solely discharge storm water may be allowed (at Regional Board discretion) compliance schedules up to 10 years from the effective date of the TMDL to achieve compliance with final WLAs.
GENERAL INDUSTRIAL STORM WATER PERMITS	
Upon permit issuance, renewal, or re-opener	The general industrial storm water permitees shall achieve dry-weather waste load allocations of zero, which shall be expressed as NPDES water quality-based effluent limitations specified in accordance with federal regulations and state policy on water quality control. Effluent limitations may be expressed as permit conditions, such as the installation, maintenance, and monitoring of Regional Board-approved BMPs. Permittees shall begin to install and test BMPs to meet the interim wet-weather WLAs. BMP effectiveness monitoring will be implemented to determine progress in achieving interim wet-weather waste load allocations.

Date	Action
5 years after effective date of the TMDLs	The general industrial storm water permittees shall achieve interim wet-weather waste load allocations, which shall be expressed as NPDES water quality-based effluent limitations. Effluent limitations may be expressed as permit conditions, such as the installation, maintenance, and monitoring of Regional Board-approved BMPs. Permittees shall beginan iterative BMP process including BMP effectiveness monitoring to achieve compliance with final waste load allocations.
10 years after the effective date of TMDL	The general industrial storm water NPDES permittees shall achieve final wet-weather waste load allocations, which shall be expressed as NPDES water quality-based effluent limitations. Effluent limitations may be expressed as permit conditions, such as the installation, maintenance, and monitoring of Regional Board-approved BMPs.
GENERAL CONSTRUCTION STORM WATER PERMITS	
Upon permit issuance, renewal, or re-opener	Non-storm water flows not authorized by Order No. 99-08 DWQ, or any successor order, shall achieve dry-weather waste load allocations of zero. Waste load allocations shall be expressed as NPDES water quality-based effluent limitations specified in accordance with federal regulations and state policy on water quality control. Effluent limitations may be expressed as permit conditions, such as the installation, maintenance, and monitoring of Regional Board-approved BMPs.
Seven years from the effective date of the TMDL	The construction industry will submit the results of wet-weather BMP effectiveness studies to the Regional Board for consideration. In the event that no effectiveness studies are conducted and no BMPs are approved, permittees shall be subject to site-specific BMPs and monitoring to demonstrate BMP effectiveness.
Eight years from the effective date of the TMDL	The Regional Board will consider results of the wet-weather BMP effectiveness studies and consider approval of BMPs no later than six years from the effective date of the TMDL.
Nine years from the effective date of the TMDL	All general construction storm water permittees shall implement Regional Board-approved BMPs.
MS4 AND CALTRANS STORM WATER PERMITS	
15 months after the effective date of the TMDL	In response to an order issued by the Executive Officer, each jurisdictional group must submit a coordinated monitoring plan, to be approved by the Executive Officer, which includes both TMDL effectiveness monitoring and ambient monitoring. Once the coordinated monitoring plan is approved by the Executive Officer, ambient monitoring shall commence.
48 months after effective date of TMDL (Draft Report) 54 months after effective date of TMDL (Final Report)	Each jurisdictional group shall provide a written report to the Regional Board outlining how the subwatersheds will achieve compliance with the waste load allocations. The report shall include implementation methods, an implementation schedule, proposed milestones, and any applicable revisions to the TMDL effectiveness monitoring plan.

Date	Action
6 years after effective date of the TMDL	Each jurisdictional group shall demonstrate that 50% of the group's total drainage area served by the storm drain system is effectively meeting the dry-weather waste load allocations and 25% of the group's total drainage area served by the storm drain system is effectively meeting the wet-weather waste load allocations.
14 years after effective date of the TMDL	Each jurisdictional group shall demonstrate that 75% of the group's total drainage area served by the storm drain system is effectively meeting the dry-weather WLAs.
18 years after effective date of the TMDL	Each jurisdictional group shall demonstrate that 100% of the group's total drainage area served by the storm drain system is effectively meeting the dry-weather WLAs and 50% of the group's total drainage area served by the storm drain system is effectively meeting the wet-weather WLAs.
22 years after effective date of the TMDL	Each jurisdictional group shall demonstrate that 100% of the group's total drainage area served by the storm drain system is effectively meeting both the dry-weather and wet-weather WLAs.

7.4 Cost Analysis

This section takes into account a reasonable range of economic factors in estimating potential costs associated with this TMDL. This analysis, together with the other sections of this staff report, CEQA checklist, response to comments, Basin Plan amendment and supporting documents, were completed in fulfillment of the applicable provisions of the California Environmental Quality Act (Public Resources Code Section 21159.)[2]

This cost analysis focuses on compliance with the grouped waste load allocation by the MS4 and Caltrans stormwater permittees in the urbanized portion of the watershed[3]. The BMPs and potential compliance approaches analyzed here could apply to the general industrial and construction storm water permittees as well. An evaluation of the costs of implementing this TMDL amounts to evaluating the costs of preventing metals and sediment from entering storm drains and/or reaching the river. Most permittees would likely implement a combination of the structural and non-structural BMPs to achieve compliance with their waste load allocations. This analysis considers a potential strategy combining structural and non-structural BMPs through a phased implementation approach and estimates the costs for this strategy. It will also be

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[2] Because this TMDL implements existing water quality objectives (namely, the numeric CTR criteria established by EPA), it does not "establish" water quality objectives and no further analysis of the factors identified in Water Code section 13241 is required. However, the staff notes that its CEQA analysis provides the necessary information to properly "consider" the factors specified in Water Code section 13241. As a result, the section 13241 analysis would at best be redundant.

[3] For the purposes of the cost analysis, the urbanized portion of the watershed is assumed to be 56% of the watershed or 467 square miles (Table 5-4).

important to document reductions in metals loading already being achieved via BMPs currently employed under the Trash TMDL.

In addition to achieving compliance with this TMDL, such a strategy could be used to achieve compliance with the Los Angeles River Trash TMDL, now in its first year of implementation,[4] as well as the upcoming Los Angeles River Bacteria TMDL. Therefore, this cost analysis reflects the potential costs of compliance with multiple TMDLs based on likely implementation scenarios.

7.4.1 Cost estimate based on a phased implementation approach. Under a phased implementation approach, it is assumed that compliance with the grouped waste load allocation could be achieved in 30% of the urbanized portion of the watershed through an integrated resources plan. Costs of implementing an IRP are not estimated for the purposes of this analysis because metals removal is not the primary goal of an IRP, which addresses multiple wastewater and water resource management needs. Compliance in another 30% of the urbanized portion of the watershed could be achieved through various iterations of non-structural BMPs. Compliance with the remaining 40% of the urbanized portion of the watershed could be achieved through structural BMPs. These percentages are approximately estimated based on the removal efficiencies of various non-structural and structural BMPs, as discussed below.

The first step of a potential phased implementation approach would include the implementation of non-structural BMPs by the permittees, such as increasing the frequency and efficiency of street sweeping. In their National Menu of Best Management Practices for Stormwater - Phase II, U.S. EPA reports that conventional mechanical street sweepers can reduce non-point source pollution by 5-30% (USEPA, 1999a.) The removal efficiencies of sediment for conventional sweepers are dependent on the size of particles. Conventional sweepers, including mechanical broom sweepers and vacuum-assisted wet sweepers, have removal efficiencies of approximately 15 to 50% for particles less than 500 micrometers and up to approximately 65% for larger particles (Walker and Wong, 1999). U.S. EPA reports that vacuum-assisted dry street sweeping can remove significantly more pollution, including fine sediment and metals, before they are mobilized by rainwater. U.S. EPA reports a 50 - 88 percent overall reduction in annual sediment loading for residential areas by vacuum-assisted dry street sweepers. Sutherland and Jelen (1997) showed a total removal efficiency of 70% for fine particles and up to 96% for larger particles by vacuum–assisted dry sweepers (also known as small-micron surface sweepers.) Upgrading to vacuum-assisted dry sweeping would translate to a significant reduction of metals in the particulate phase.

In their 1999 Preliminary Data Summary of Urban Stormwater Best Management Practices, U.S. EPA estimated cost data for both standard mechanical and vacuum-assisted dry sweepers as shown in Table 7-5.

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[4] Pursuant to a court order, certain cities are presently exempted from compliance with the Los Angeles River Trash TMDL. The Los Angeles River Trash TMDL is also the subject of judicial appeal. Regardless of the outcome of the judicial challenge, there will be a trash TMDL for the Los Angeles River, because a TMDL is compelled under the *Heal the Bay* consent decree. As a result, coordination among the TMDLs will remain a possibility.

Table 7-5. Estimated costs for two types of street sweepers.

Sweeper Type	Life (Years)	Purchase Price ($)	O&M Cost ($/curb mile)
Mechanical	5	75,000	30
Vacuum-assisted	8	150,000	15

Source: USEPA, 1999b

Table 7-5 illustrates that while the purchase price of vacuum-assisted dry sweepers is higher, the operation and maintenance costs are lower than for standard sweepers. Based on this information, U.S. EPA determined the total annualized cost of operating street sweepers per curb mile, for a variety of frequencies (in Table 7-6). In their estimates, U.S. EPA assumed that one sweeper serves 8,160 curb miles during a year and assumed an annual interest rate of 8 percent (USEPA, 1999b). According to Table 7-6, permittees would save money in the long-term by switching to vacuum-assisted dry sweepers.

Table 7-6. Annualized sweeper costs, including purchase price and operation and maintenance costs ($/curb mile/year).

Sweeper Type	Sweeping Frequency					
	Weekly	Bi-weekly	Monthly	Quarterly	Twice per year	Annually
Mechanical	1,680	840	388	129	65	32
Vacuum-Assisted	946	473	218	73	36	18

Under a phased implementation approach, the permittees could monitor compliance using flow-weighted composite sampling of runoff throughout representative storms to determine the effectiveness of this first step of implementing non-structural BMPs. If monitoring showed non-compliance, permittees could adapt their approach by increasing frequency of street sweeping or incorporating other non-structural BMPs.

If compliance could still not be achieved through non-structural BMPs, permittees could incorporate structural BMPs. Two potential structural BMPs were analyzed in this cost analysis:

1. Infiltration trenches
2. Sand filters

These approaches are specifically designed to treat urban runoff and to accommodate high-density areas. They were chosen for this analysis because in addition to addressing metals loadings to the river, they have the additional positive impact of addressing the effects of development and increased impervious surfaces in the watershed. Both approaches can be designed to capture and treat 0.5 to 1 inch of runoff. When flow exceeds the design capacity of each device, untreated runoff is allowed to bypass the device and enter storm drains or the river.

Both infiltration trenches and sand filters must be used in conjunction with some type of pretreatment device such as a biofiltration strip or gross solids removal device to remove sediment and trash in order to increase their efficiency and service life. This combination could be used to achieve compliance with both the Los Angeles River Trash TMDL and the Metals TMDL. The Trash TMDL provided a cost estimate of gross solids removal devices, including structural vortex separation systems and end of pipe nets. This analysis provides an estimate of the additional costs associated with installing sand filters or infiltration trenches.

In addition, both infiltration trenches and sand filters are efficient in removing bacteria and could be used to achieve compliance with the upcoming bacteria TMDL. U.S. EPA reports that sand filters have a 76% removal rate and infiltration trenches have a 90% removal rate for fecal coliform. (U.S. EPA 1999c)

In this cost analysis, it was assumed that 20% of the watershed would be treated by infiltration trenches and 20% of the watershed would be treated by sand filters. Costs were estimated using data provided by U.S. EPA (U.S. EPA, 1999a and 1999c) and the Federal Highway Administration (FHWA, 2003). USEPA cost data were reported in 1997 dollars. FHWA costs were reported in 1996 dollars for infiltration trenches and 1994 dollars for sand filters. Where costs were reported as ranges, the highest reported cost was assumed. These costs were then compared to costs determined by Caltrans in their BMP Retrofit Pilot Program (Caltrans, 2004). Caltrans costs were reported in 1999 dollars. Analysis of costs based on EPA, FHWA estimates and those reported by Caltrans, as well as estimations of sizing constraints are included in Appendix III. An analysis of size constraints for each type of structural BMP considered is also included in Appendix III, which could be used to estimate land acquisition costs. To estimate land acquisition cots for individual projects in this cost analysis would be purely speculative.

Infiltration trenches. Infiltration trenches store and slowly filter runoff through the bottom of rock-filled trenches and then through the soil. Infiltration trenches can be designed to treat any amount of runoff, but are ideal for treating small urban drainage areas less than five to ten acres. Soils and topography are limiting factors in design and siting, as soils must have high percolation rates and groundwater must be of adequate depth. Potential impacts to groundwater by infiltration trenches could be avoided by proper design and siting. Infiltration trenches are reported to achieve 75 to 90% suspended solids removal and 75-90% metals removal by U.S. EPA and FHWA. In their BMP Retrofit Pilot Program, Caltrans assumed that constituent removal was 100 percent for storm events less than the design storm, because all runoff would be infiltrated.

Table 7-7 presents estimated costs for infiltration trenches designed to treat 0.5 inches of runoff over a five-acre drainage area with a runoff coefficient equal to one. Staff determined that 11,955 devices, designed to treat five acres each, would be required to treat 20% of the urbanized portion of the watershed.

Table 7-7. Estimated costs for infiltration trenches.

	Construction Costs ($ million)	Maintenance Costs ($ million/year)
Based on U.S. EPA estimate (1997 dollars)	544	109
Based on FHWA estimate (1996 dollars)	519	Not reported

Sand Filters. Sand filters work by a combination of sedimentation and filtration. Runoff is temporarily stored in a pretreatment chamber or sedimentation basin, then flows by gravity or is pumped into a sand filter chamber. The filtered runoff is then discharged to a storm drain or natural channel. As with infiltration trenches, The costs of two types of sand filters were analyzed: 1) the Delaware sand filter, which is installed underground and suited to treat drainage areas of approximately one acre and 2) the Austin sand filter, which is installed at-grade and suited to larger drainage areas up to 50 acres. The underground sand filter is especially well adapted for applications with limited land area and is independent of soil conditions and depth to groundwater. However, both approaches must consider the imperviousness of the drainage areas in their design.

U.S. EPA estimated a 70% removal of total suspended solids and 45% removal of lead and zinc for both types of sand filters. FHWA reported high sediment, zinc and lead removal, but low copper removal for Austin sand filters and high sediment and moderate to high metals removal for Delaware sand filters. Caltrans reported a 50% reduction in total copper, a 7% reduction in dissolved copper, an 87% reduction in total lead, a 40% reduction in dissolved lead, an 80% reduction in total zinc and a 61% reduction in dissolved zinc by the Austin sand filters they tested. Caltrans reported a 66% reduction in total copper, a 40% reduction in dissolved copper, an 85% reduction in total lead, a 31% reduction in dissolved lead, a 92% reduction in total zinc and a 94% reduction in dissolved zinc by the Delaware sand filter they tested.

U.S. EPA and FHWA reported costs per acre for 0.5 inches of runoff. Total costs were calculated by multiplying the per-acre cost by the total acreage of the urbanized portion of the watershed not addressed through an integrated resources plan or non-structural BMPs. Estimated costs are presented in Table 7-8. There are significant economies of scale for Austin filters. U.S. EPA reported that costs per acre decrease with increasing drainage area. FHWA reported two separate costs based on drainage area served. Economies of scale are not a factor for Delaware filters, as they are limited to drainage areas of about one acre.

Table 7-8. Estimated costs for Austin and Delaware sand filters.

	Austin Sand Filter Construction Costs ($ million)	Austin Sand Filter Maintenance Costs ($ million/year)	Delaware Sand Filter Construction Costs ($ million)	Delaware Sand Filter Maintenance Costs ($ million/year)
Based on U.S. EPA estimate (1997 dollars)	553	28	329	16
Based on FHWA estimate (1994 dollars)*	102	Not reported	418	Not reported

*FHWA cost estimate for Austin filters calculated assuming a drainage area greater than five acres. Total costs would be $478 million for devices designed for a drainage area of less than two acres.

Based on the phased implementation approach, and some assumptions about the efficacy of each stage of the approach, the cost analysis arrived at the total costs for compliance with the Metals TMDL as shown in Table 7-9. The total costs do not include the cost savings associated with switching to vacuum-assisted street sweepers. As stated previously, the costs associated with this approach could be applied towards the cost of compliance with both the Metals TMDL and Bacteria TMDL.

Table 7-9. Total estimated costs of phased implementation approach.

	Total Construction ($ million)	Total Maintenance ($million/year)
Based on U.S. EPA estimate (1997 dollars)	1426	153
Based on FHWA estimate (1994/1996 dollars)	1039	Not reported

7.4.2 Comparison of costs estimates with Caltrans reported costs. Estimated costs for structural BMPs were compared to costs reported by Caltrans in their BMP Retrofit Pilot Program (Caltrans, 2004). Caltrans sited five Austin sand filters and one Delaware sand filter as part of their study. The five Austin sand filters served an average area of two acres and the Delaware sand filter served an area of 0.7 acres. Caltrans sited two infiltration trench/biofiltration strip combinations as part of their study. Each trench and biofiltration strip used in combination served an area of 1.7 acres. Based on these drainage areas, the average adjusted cost of the Austin sand filters in the Caltrans study was $156,600 per acre, the adjusted cost of the Delaware filter was $310,455 per acre and the average adjusted cost of the infiltration trench/biofiltration strips was $85,495 per acre. These costs are approximately an order of magnitude greater than the costs determined using estimates provided by U.S. EPA and FHWA. It should be noted that costs calculated using EPA and FHWA estimates were based on infiltration trench and sand filter designs that would treat 0.5 inches of runoff, while the Caltrans study costs were based on an infiltration trench design that would treat 1 inch of runoff and sand filter designs that would treat 0.56 to 1 inches of runoff. This could explain some of the differences in costs.

The differences in costs can also be explained by a third party review of the Caltrans study, conducted by Holmes & Narver, Inc. and Glenrose Engineering (Caltrans, 2001.) The review compared adjusted Caltrans costs with costs of implementing BMPs by other state transportation agencies and public entities. The adjusted costs exclude costs associated with the unique pilot program and ancillary costs such as improvements to access roads, landscaping or erosion control, and non-BMP related facilities. For the comparison, all costs were adjusted for differences in regional economies. The third party review determined that the median costs reported by Caltrans were higher than the median costs reported by the other agencies for almost every BMP considered, including sand filters and infiltration BMPs. The review attributed the higher Caltrans costs to the small scale and accelerated nature of the pilot program. The third party review then gave recommendations for construction cost reductions based on input from other state agencies. These included simplifying design and material components, combining retrofit work with ongoing construction projects, changing methods used to select and work with construction contractors, allowing for a longer planing horizon, constructing a larger number of BMPs at once, and implementing BMPs over a larger drainage area.

7.4.3 Results of a Region-wide Cost study

In their report entitled "Alternative Approaches to Storm Water Quality Control, Prepared for the Los Angeles Regional Water Quality Board," Devinny et al. estimated the total costs for compliance with Regional Board storm water quality regulations as ranging from \$2.8 billion, using entirely non-structural systems, to between \$5.7 billion and \$7.4 billion, using regional treatment or infiltration systems. The report stated that final costs would likely fall somewhere within this range. Table 7-10 presents the report's estimated costs for the various types of structural and non-structural systems that could be used to achieve compliance with municipal storm water requirements throughout the Region.

Table 7-10 Estimated costs of structural and non-structural compliance measures for the entire Los Angeles Region. (Source: Devinny et al.)

Compliance Approach	Estimated Costs
Enforcement of litter ordinances	\$9 million/year
Public Education	\$5 million/year
Increased storm drain cleaning	\$27 million/year
Installation of catch basin screens, enforcing litter laws, improving street cleaning	\$600 million
Low –flow diversion	\$28 million
Improved street cleaning	\$7.5 million/year
On-site BMPs for individual facilities	\$240 million
Structural BMPs – 1st estimation method	\$5.7 billion
Structural BMPs – 2nd estimation method	\$4.0 billion

The Devinny et al. study calculates costs for the entire Los Angeles Region, which is 3,100 square miles, while the Los Angeles River watershed is 834 square miles. When compared on a per square mile basis, the costs estimated in section 7.4.2 are within the range calculated by Devinny et al. Table 7-11 gives the estimated costs presented per square mile.

Table 7-11 Comparison of costs for storm water compliance on a per mile basis.

	Construction Costs ($ million/square mile)
Based on U.S. EPA estimate	1.71
Based on FHWA estimate	1.25
Maximum cost calculated by Devinny et al.	0.90 – 2.39

The Devinny et al. study also estimated benefits associated with storm water compliance. It was determined that the Region-wide benefits of a non-structural compliance program would equal approximately $5.6 billion while the benefits of non-structural and regional measures would equal approximately $18 billion. Region-wide estimated benefits included:

- Flood control savings due to increased pervious surfaces of about $400 million,
- Property value increase due to additional green space of about $5 billion,
- Additional groundwater supplies due to increased infiltration worth about $7.2 billion,
- Willingness to pay to avoid storm water pollution worth about $2.5 billion,
- Cleaner streets worth about $950 million,
- Improved beach tourism worth about $100 million (not applicable to Los Angeles River),
- Improved nutrient recycling and atmospheric maintenance in coastal zones worth about $2 billion,
- Savings from reduction of sedimentation in Regional harbors equal to about $330 million, and
- Unquantifiable health benefits of reducing exposure to fine particles from streets.

8. MONITORING

There are three objectives of monitoring associated with the TMDL. The first is to collect data (e.g., hardness, flow, and background concentrations) to evaluate the uncertainties and assumptions made in development of the TMDL. The second is to collect data to assess compliance with the waste load allocations. The third is to collect data to evaluate potential management scenarios. To achieve these objectives, a monitoring program will need to be developed for the TMDL that consists of three components: (1) ambient monitoring, (2) compliance assessment monitoring and (3) special studies.

The monitoring program and any required technical reports will be established pursuant to a subsequent order issued by the Executive Officer. As a planning document, the TMDL identifies the type of information necessary to refine and to update the TMDL, and to assess the TMDL's effectiveness. The Executive Officer will comply with any necessary legal requirements in developing the monitoring program, requiring technical reports, and establishing special studies.

8.1 Ambient Monitoring

An ambient monitoring program is necessary to assess water quality throughout the Los Angeles River and its tributaries. The MS4 and caltrans NPDES permittees assigned waste load allocations in each jurisdictional group are jointly responsible for implementing the ambient monitoring program. The responsible agencies shall sample for total recoverable metals, dissolved metals, and hardness once per month at each ambient monitoring location until at least year five when the TMDL is reconsidered. There are eight proposed ambient monitoring points on the Los Angeles River to reflect the reaches and the monitoring stations (Table 8-1). These stations correspond to the City of Los Angeles Watershed Monitoring Stations. The City currently samples for metals at these eight monitoring stations once per month. In early 2004, the City began sampling for hardness with the same frequency. The City plans to extend and modify their program to include metals sampling of the tributaries in the future.

Table 8-1. Ambient monitoring points on the Los Angeles River.

Ambient Monitoring Points	Corresponding Reaches
White Oak Avenue	LA River 6, Aliso Creek, McCoy Creek, Bell Creek
Sepulveda Avenue	LA River 5, Bull Creek
Tujunga Avenue	LA River 4, Tujunga Wash
Colorado Avenue	LA River 3, Burbank Western Channel, Verdugo Wash
Figueroa Street	LA River 3, Arroyo Seco
Washington Boulevard	LA River 2
Rosecrans Avenue	LA River 2, Rio Hondo
Willow Street	LA River 1, Compton Creek

8.2 TMDL Effectiveness Monitoring

TMDL effectiveness monitoring requirements for implementation will be specified in NPDES permits for the Tillman, LA-Glendale, and Burbank POTWs. The permits should specify the monitoring necessary to determine if the expected load reductions are achieved.
For the Tillman, LA-Glendale, and Burbank POTWs, effluent monitoring requirements will be developed to ensure compliance with the daily and monthly limits for metals. Receiving water

monitoring requirements in the existing permits to assess impact of the POTWs will not change as a result of this TMDL.

The general industrial storm water permit shall contain a model monitoring and reporting program to evaluate BMP effectiveness. A permittee enrolled under the general industrial permit shall have the choice of conducting individual monitoring based on the model program or participating in a group monitoring effort. A group monitoring effort will not only assess individual compliance, but will assess the effectiveness of chosen BMPs to reduce pollutant loading on an industry-wide or permit category basis. MS4 permittees are encouraged to take the lead in group monitoring efforts for industrial and construction facilities within their jurisdiction because compliance with waste load allocations by these facilities will translate to reductions in metals loads to the MS4 system.

The MS4 and Caltrans storm water NPDES permittees in each jurisdictional group are jointly responsible for assessing progress in reducing pollutant loads to achieve the TMDL. Each jurisdictional group is required to submit for approval by the Executive Officer a coordinated monitoring plan that will demonstrate the effectiveness of the phased implementation schedule for this TMDL which requires that the waste load allocations be met in prescribed percentages of each subwatershed over a 22-year period. The monitoring locations specified for the ambient monitoring program (Table 8-1) may be used as effectiveness monitoring locations.

The storm water NPDES permittees will be found to be effectively meeting the dry-weather waste load allocations if the in-stream pollutant concentration or load at the first downstream effectiveness monitoring location is equal to or less than the corresponding concentration- or load-based waste load allocation. Alternatively, effectiveness of the TMDL may be assessed at the storm drain outlet based on the numeric target for the receiving water. For storm drains that discharge to other storm drains, effectiveness will be based on the waste load allocation for the ultimate receiving water for that storm drain system.

The storm water NPDES permittees will be found to be effectively meeting wet-weather waste load allocations if the loading at the downstream monitoring location is equal to or less then the daily storm volume multiplied by the wet-weather numeric targets as defined in Table 6-12. For practical purposes, this is when the EMC is less than or equal to the numeric target.

8.3 Special Studies

Additional monitoring and special studies may be needed to evaluate the uncertainties and the assumptions made in development of this TMDL.

1. Flow measurements. Better information is needed to define flow in the mainstem of the Los Angeles River and the tributaries where there are no stream gages. The biggest uncertainties are associated with low-flow in some of the listed tributaries. Better information is also needed about contributions of storm drains during low flow, where needed.

2. Water quality measurements. Information on background water quality will help refine the targets. Specifically, studies should be developed to provide a better assessment of background

hardness values in areas where the data are old (lower reaches of Los Angeles River and Rio Hondo) or non-existent (Tujunga, Verdugo Wash, Arroyo Seco). Studies on background concentrations of total suspended solids and organic carbon will help with the refinement of the use of partition coefficients to define metals conversion factors.

3. Effects studies. Special studies may be warranted to evaluate the targets. Los Angeles County Sanitation District and others are testing an approach to use the Biotic Ligand Model in the Los Angeles Region. Measurements of dissolved organic carbon, alkalinity, humic acid, and alkali/alkaline metals would support this effort.

4. Source studies. There is a need for better characterization of the loadings from natural sources to verify the assumptions that the loadings from natural sources for copper, lead and zinc are generally low. A study should also be developed to verify the assumption that selenium concentrations observed in the upper reaches of the Los Angeles River are from natural background sources.

5. Other special studies. Special studies should also be considered to refine some of the assumptions used in the modeling, specifically the relationship between total recoverable and dissolved metals in storm water, the assumption that metals loadings are closely associated with suspended sediments, the accuracy and robustness of the potency factors, and the uncertainties in the understanding sediment washoff and transport. Studies should also be considered to evaluate the potential contribution of aerial deposition to metals loadings and sources of aerial deposition.

6. POTWs that are unable to demonstrate compliance with final waste load allocations must conduct source reduction audits within two years of the effective date of the TMDL.

7. POTWs that will be requesting the Regional Board to extend their implementation schedule to allow for the installation of advanced treatment must prepare work plans with time schedules to allow for the installation and operation of advanced treatment. The work plan must be submitted within four years from the effective date of the TMDL.

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Figure 1. Map of the Los Angeles River watershed and listed reaches.

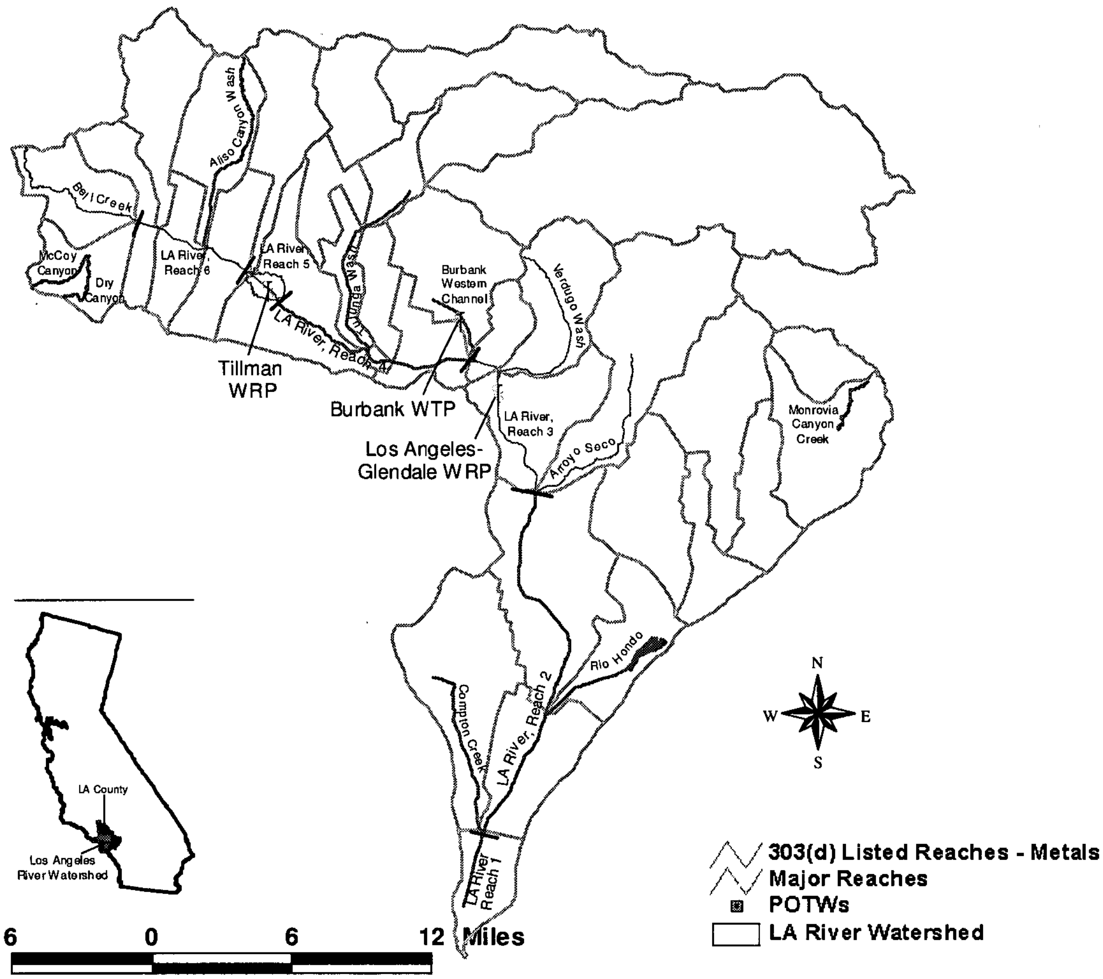


Figure 2. Sampling stations in the Los Angeles River watershed.

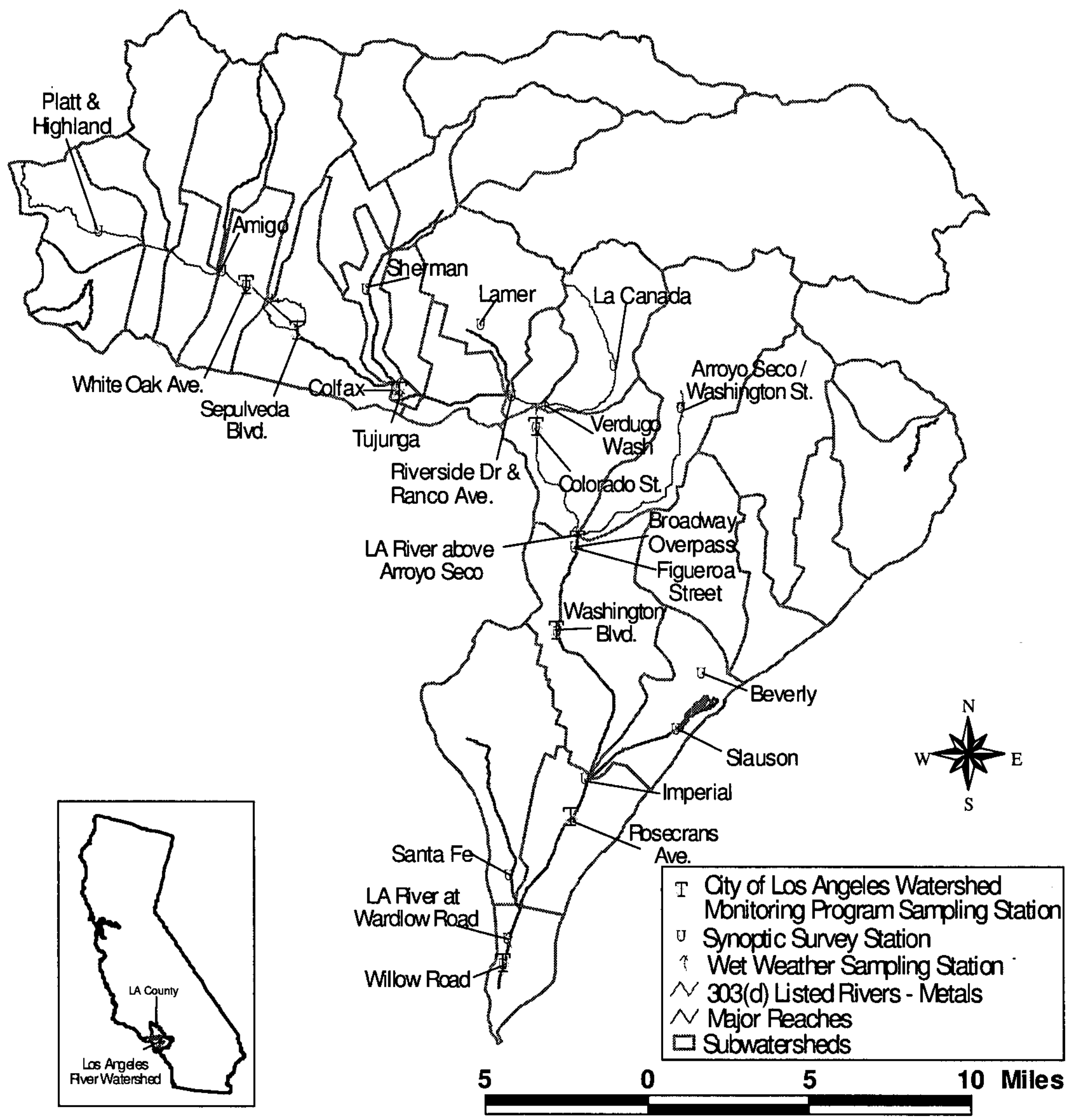
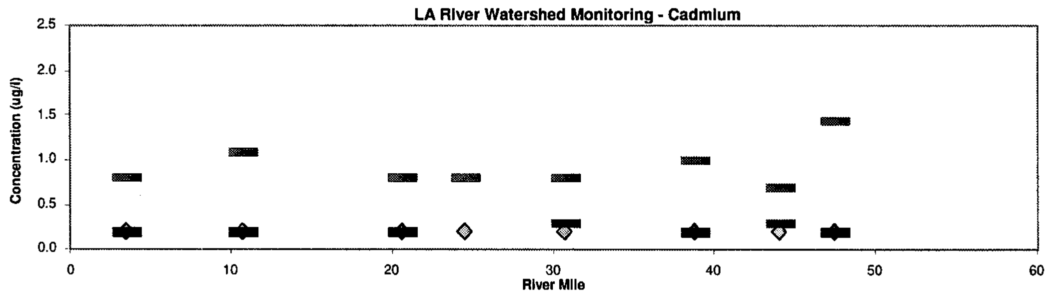


Figure 3. Data collected by the City of Los Angeles Watershed Monitoring Program.

3a.



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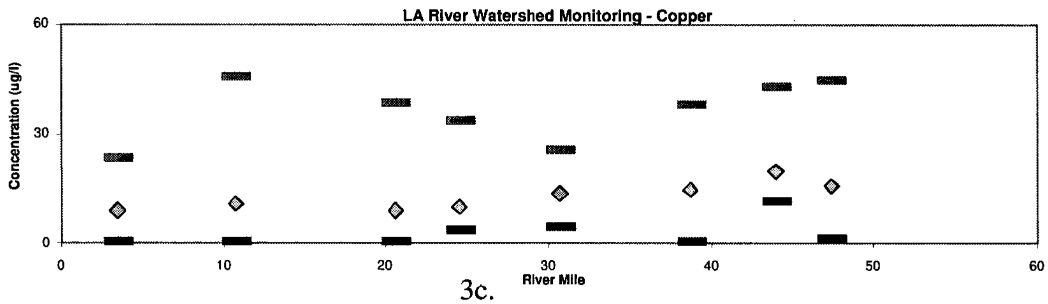

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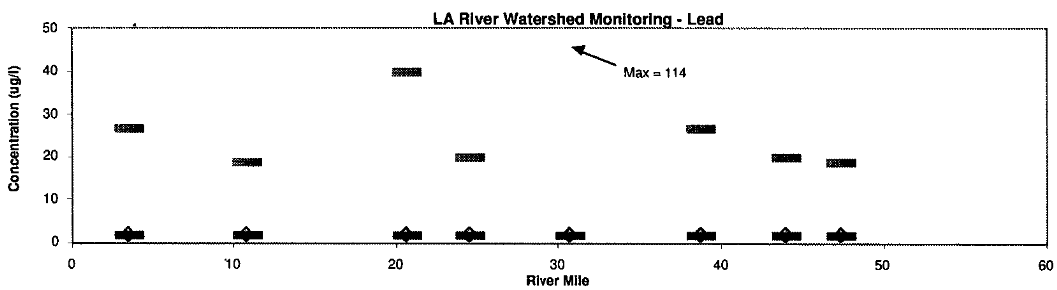

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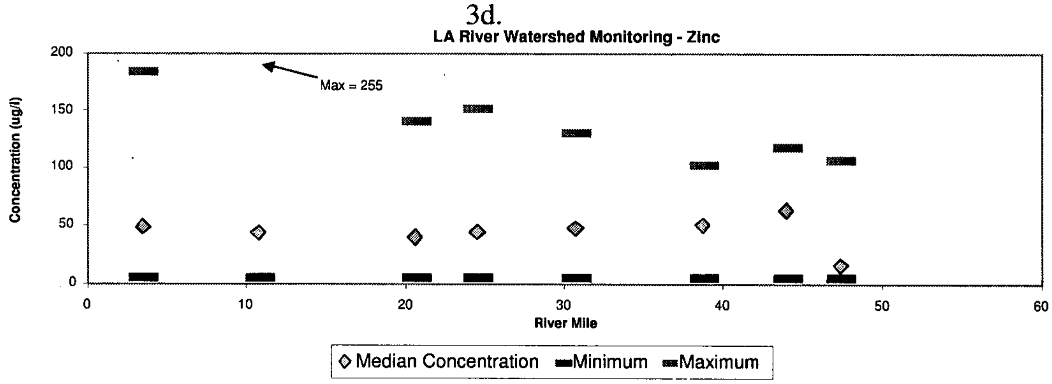


Figure 4. Flows at Wardlow (1998-2000)

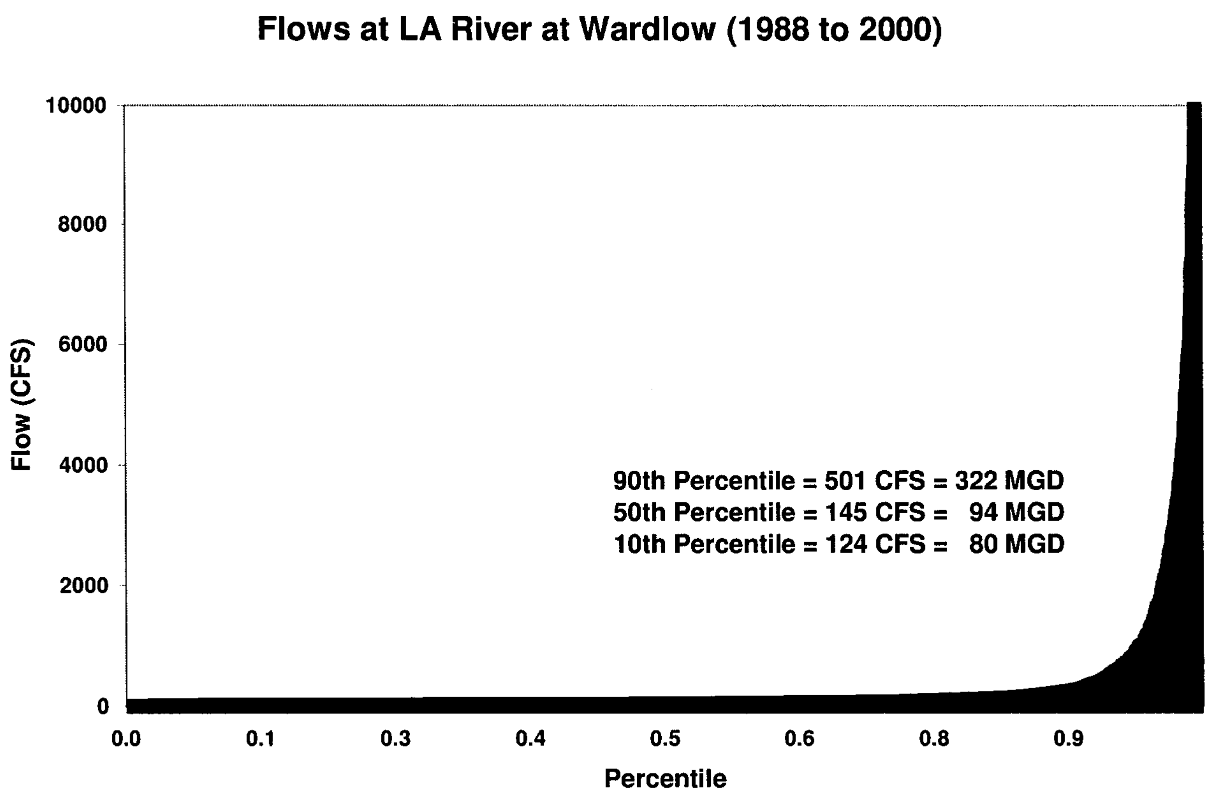


Figure 5. Location of stream gages in the Los Angeles River watershed.

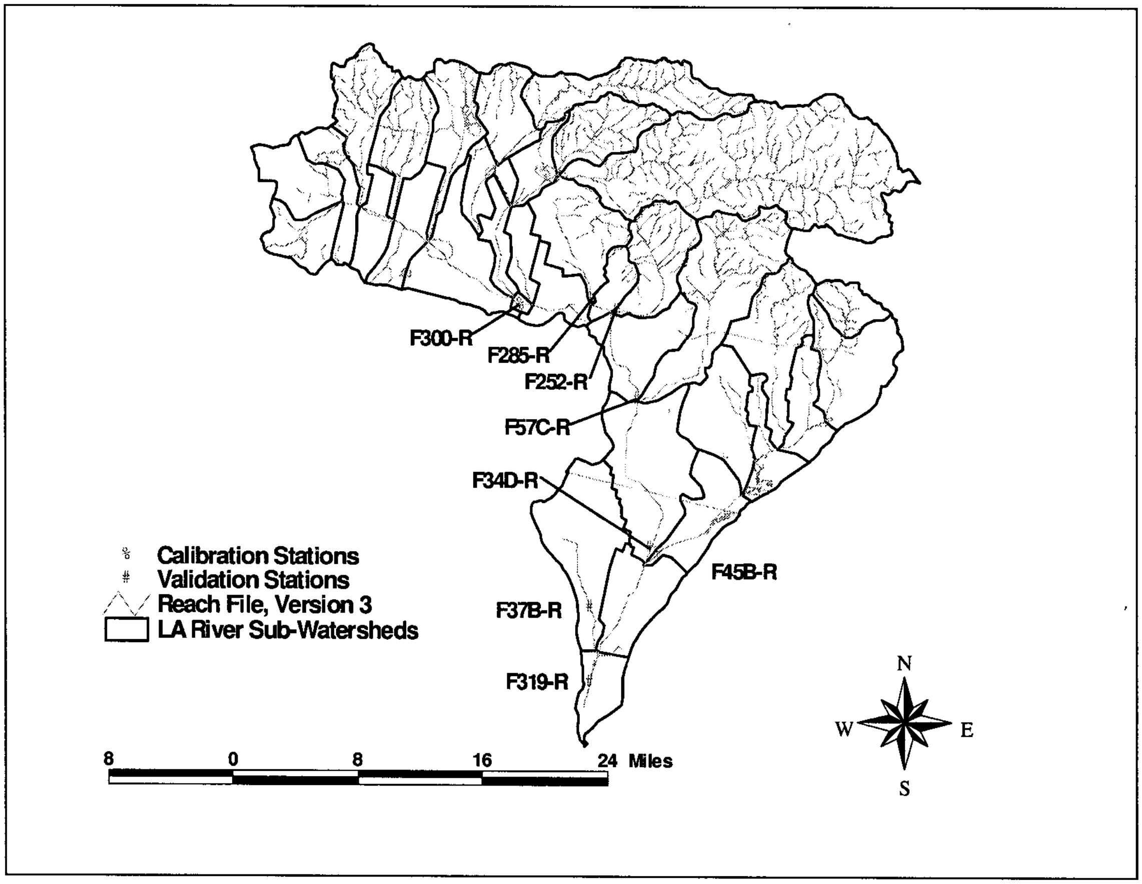


Figure 6. Simulated vs. measured flow during 2000 low flow period.

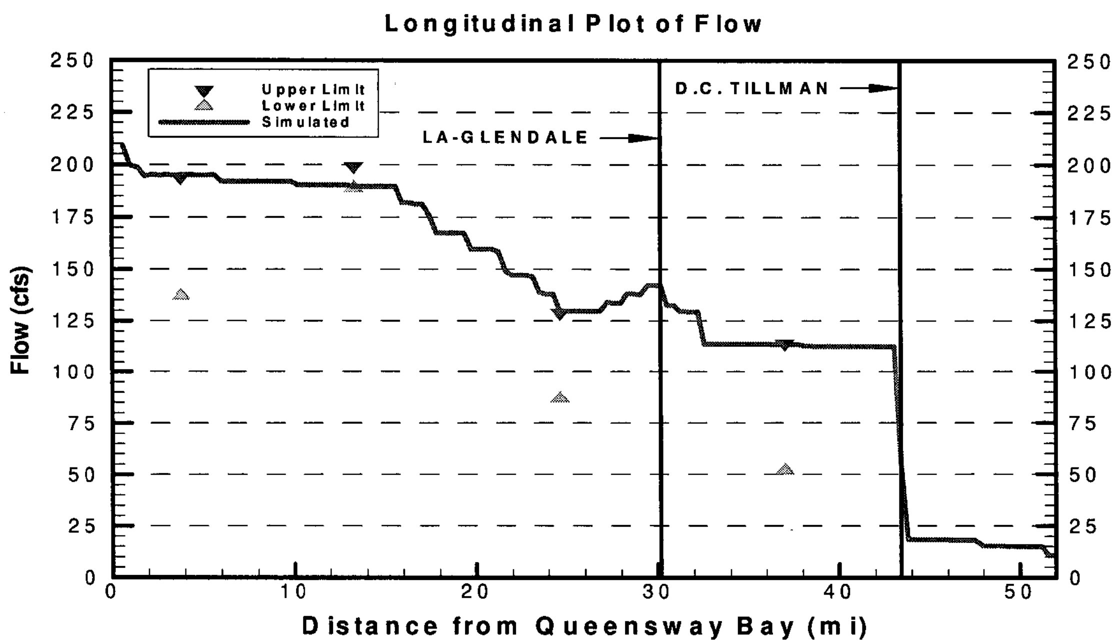
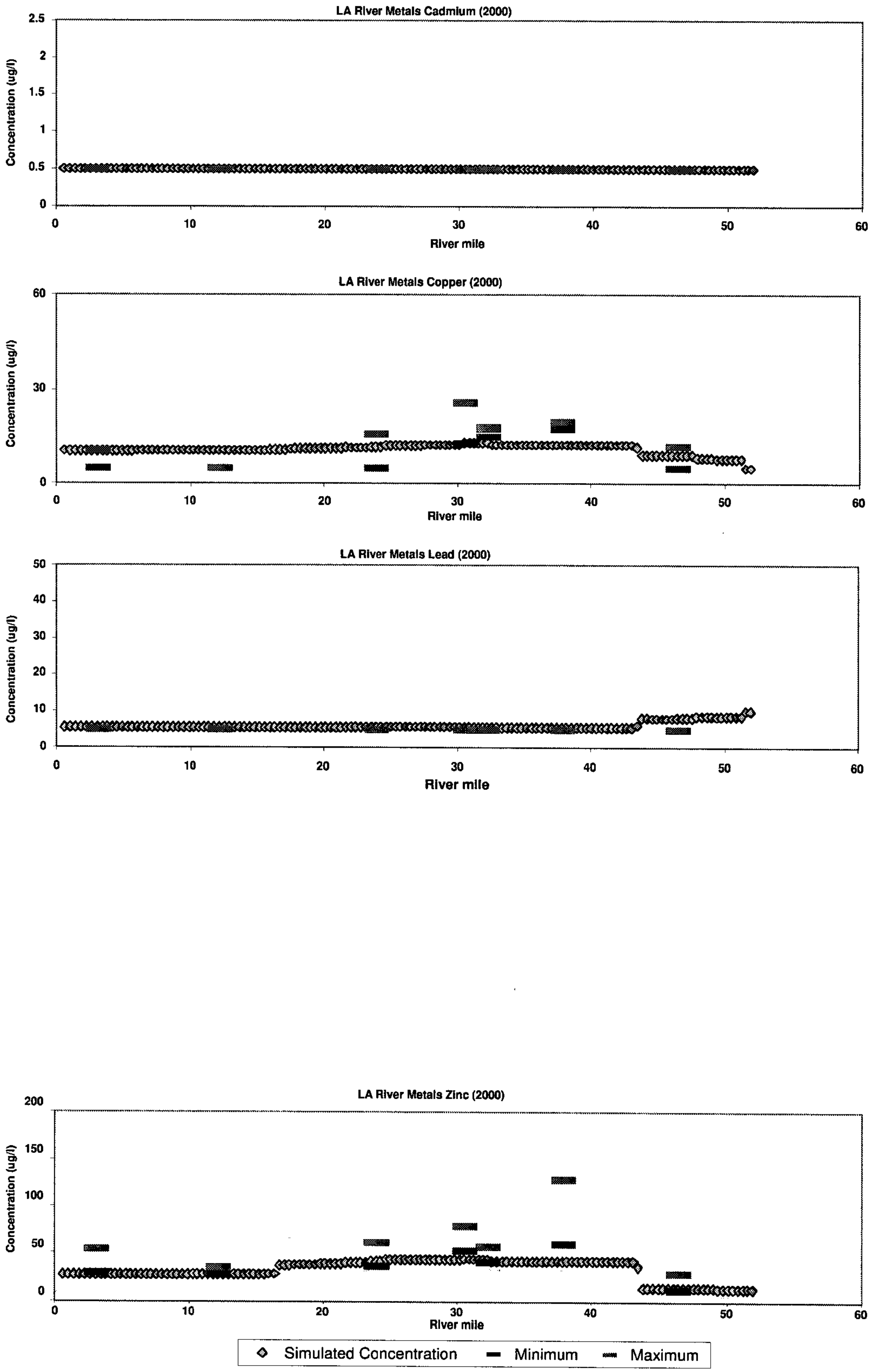
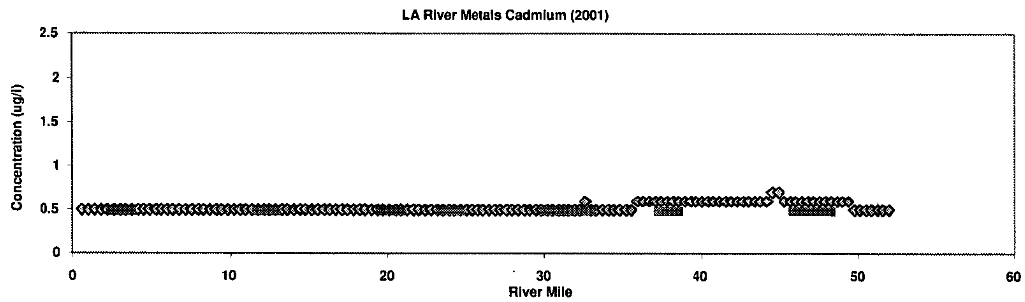
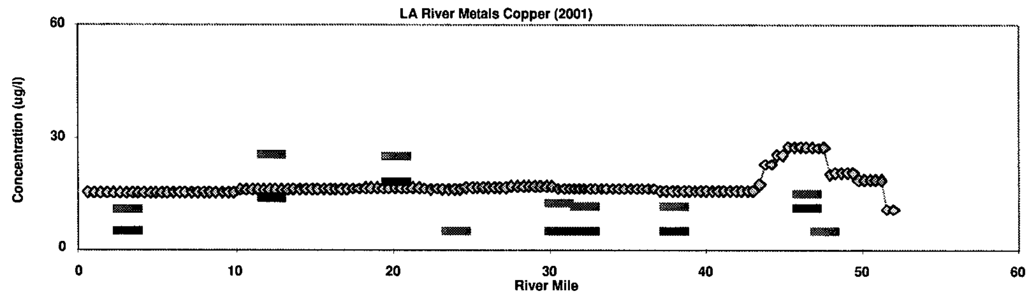
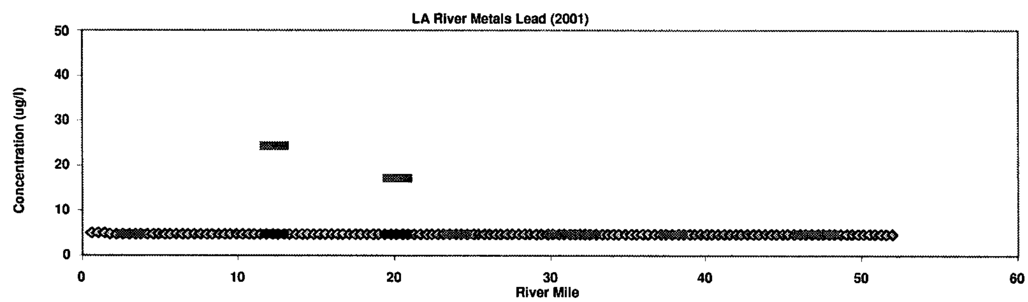


Figure 7. Comparison of the dry-weather water quality model results with observed data.




LA River Metals Cadmium (2001)
Concentration (ug/l)
River Mile


LA River Metals Copper (2001)
Concentration (ug/l)
River Mile


LA River Metals Lead (2001)
Concentration (ug/l)
River Mile

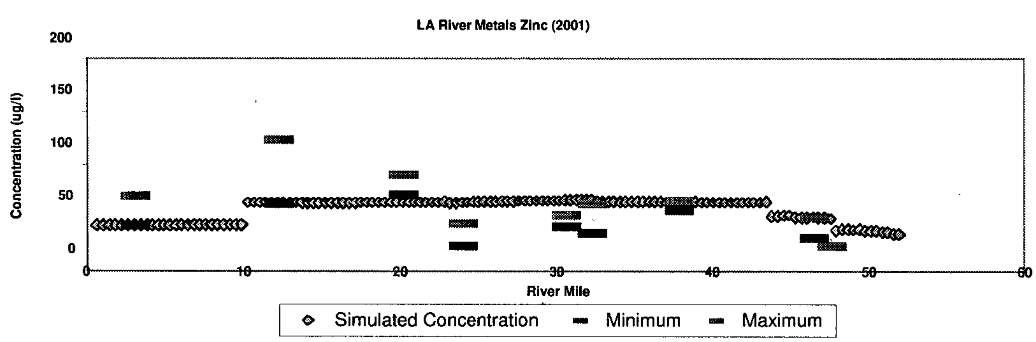

LA River Metals Zinc (2001)
Concentration (ug/l)
River Mile
Simulated Concentration
Minimum
Maximum

Figure 8. Los Angeles River sub-watershed delineation used in wet-weather model.

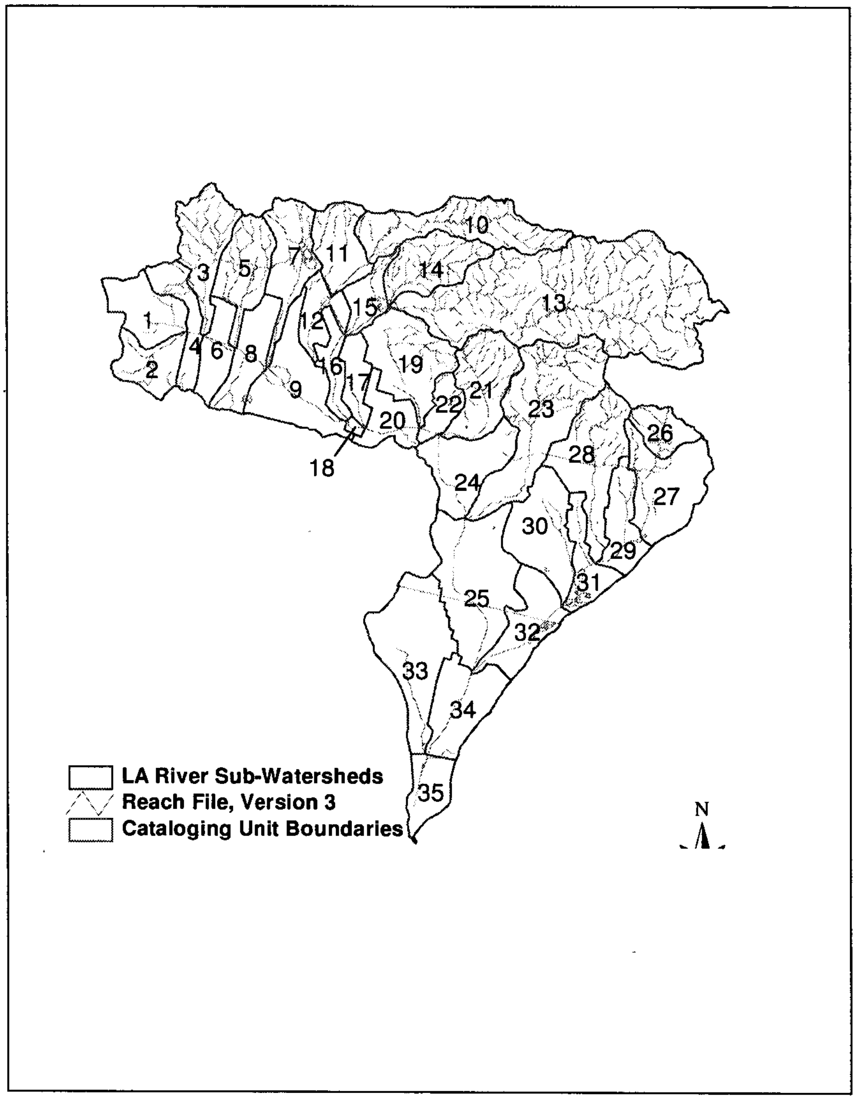


Figure 9. Location of precipitation and meteorological stations used in wet-weather model.

Figure 10a. Validation of wet-weather hydrography. Comparison of daily flows.

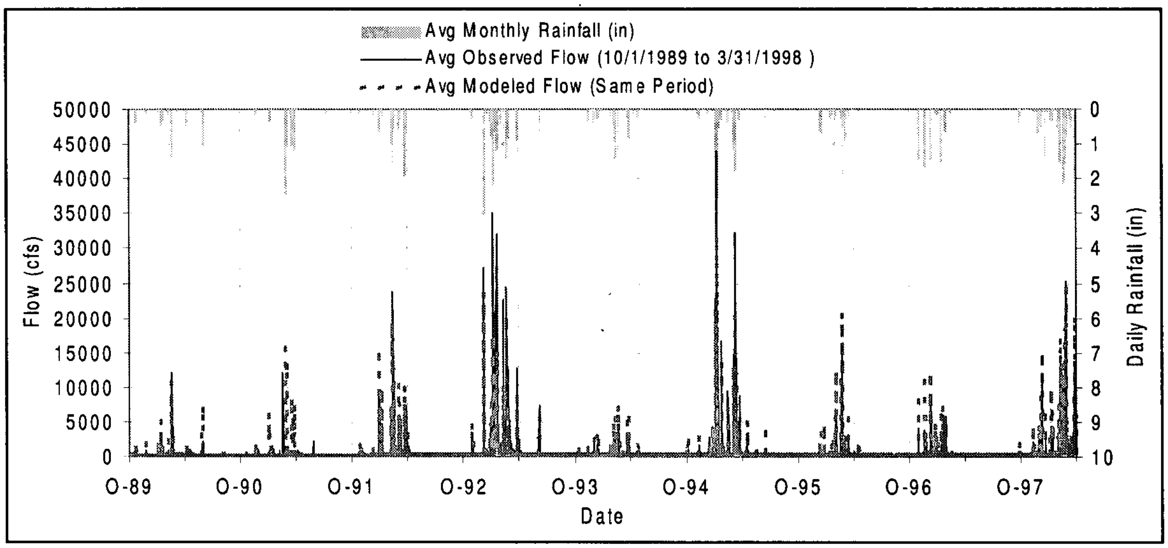


Figure 10b. Validation of wet-weather hydrography. Regression of monthly flows.

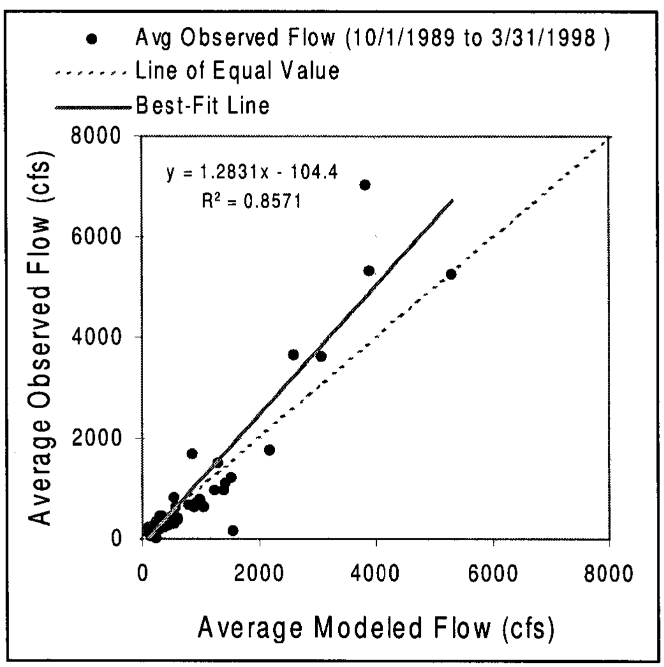


Figure 11. Example Load Duration Curve

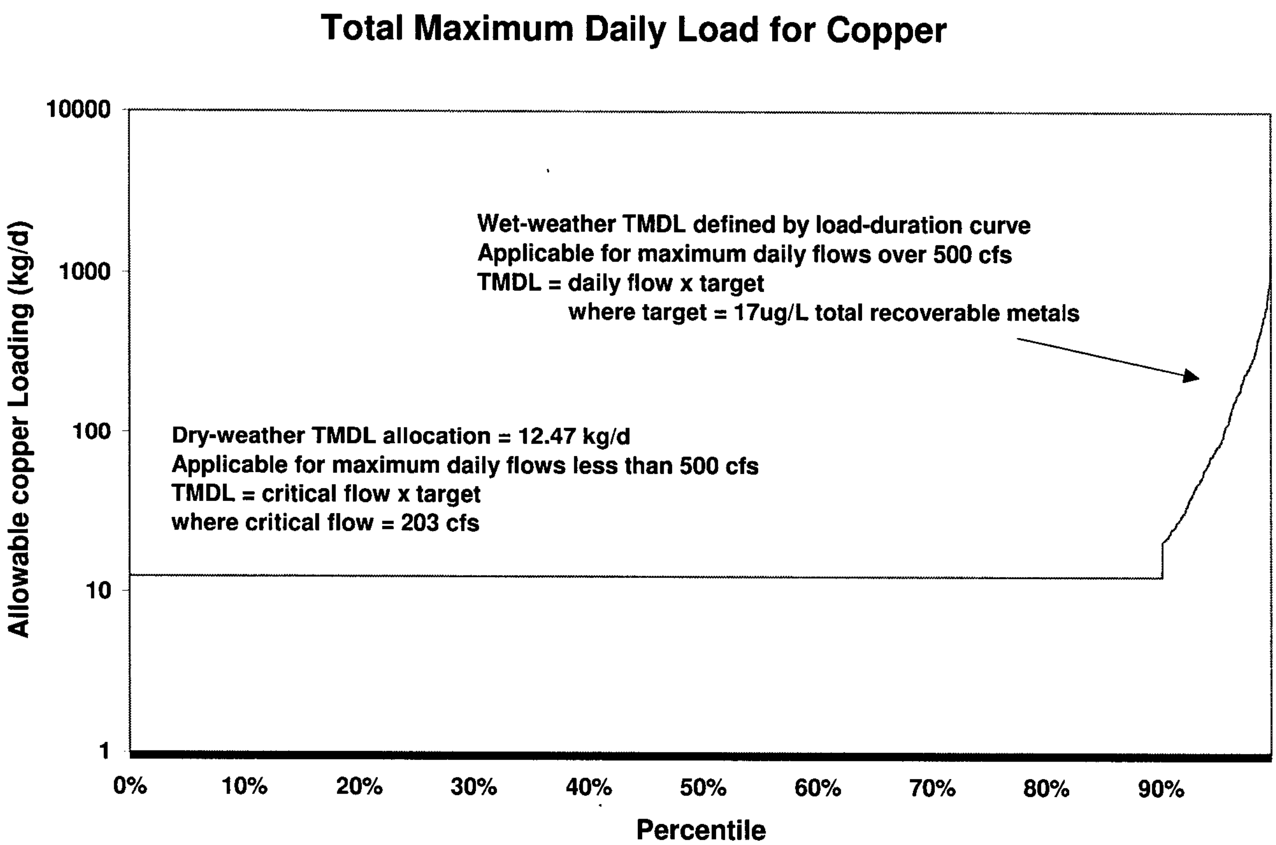
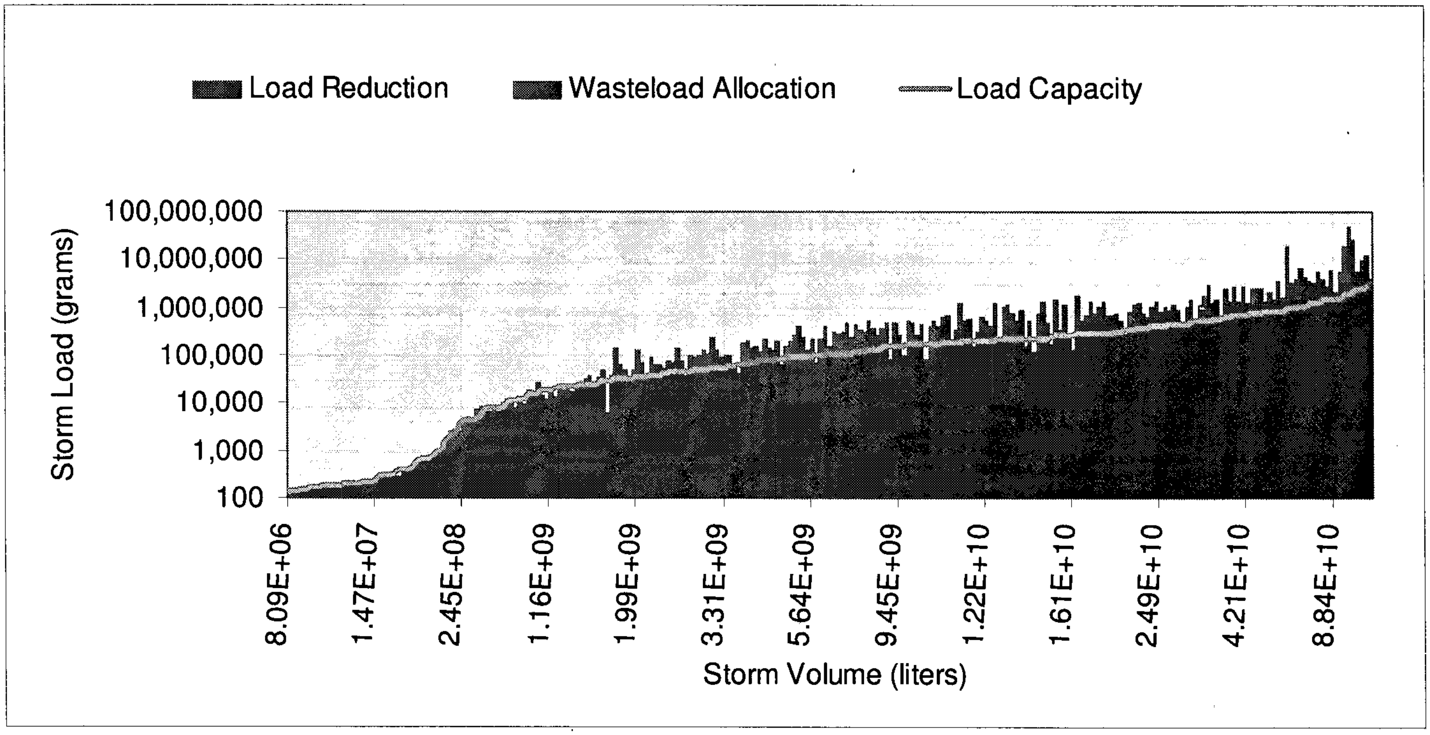


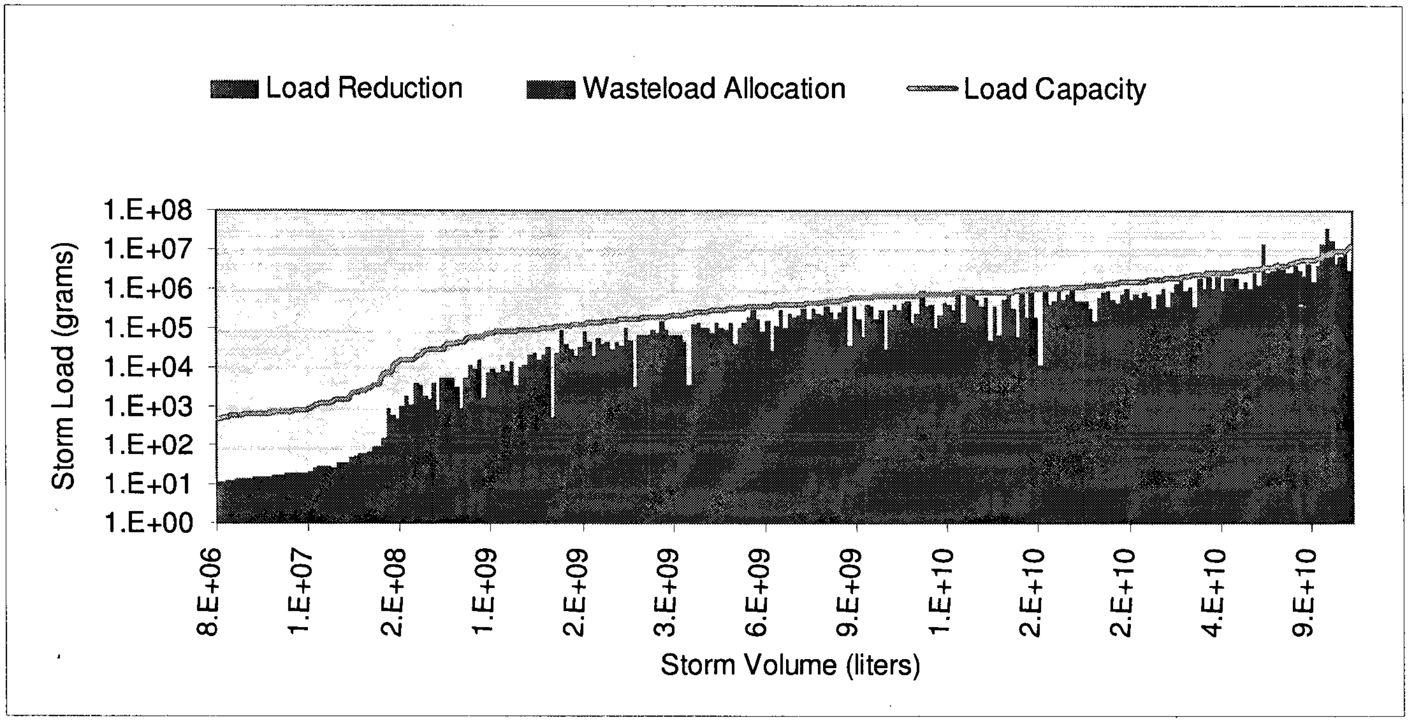
Figure 12a. Load-duration curve for copper



Computed Load Indicators:	Value	Units
Total Storms Over 12-Year Period	249	none
Total Below Load Capacity Curve:	70,590	kg
Existing Condition (Red and Blue)	297,889	kg
Existing Load Below Load Capacity Curve (Blue):	69,706	kg
Existing Load Above Load Capacity Curve (Red):	228,183	kg
Estimated Load Reduction*:	76.6%	none

* Model predictions tend to overestimate loadings. Actual reductions required to meet the waste load allocations as defined by the load capacity curve may be less.

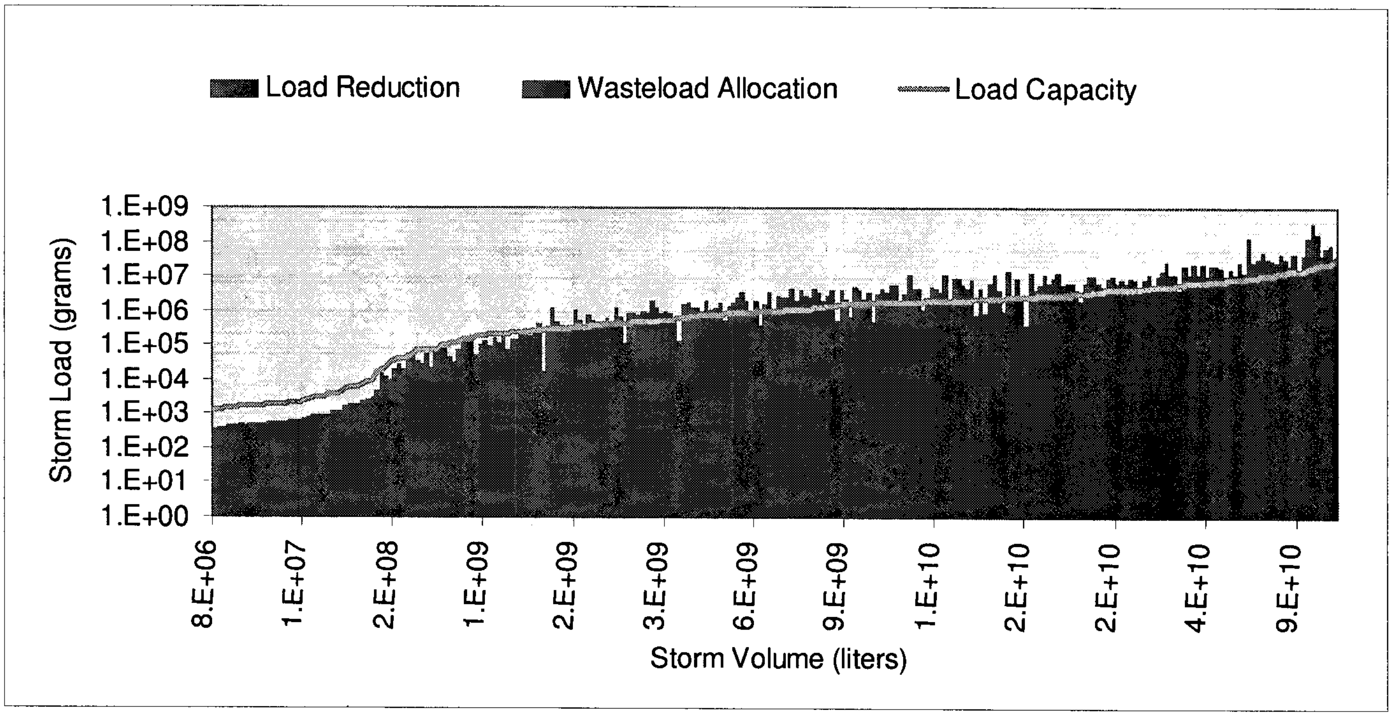
Figure 12b. Load-duration curve for lead



Computed Load Indicators:	Value	Units
Total Storms Over 12-Year Period		none
Total Below Load Capacity Curve:	259,431	kg
Existing Condition (Red and Blue)	211,484	kg
Existing Load Below Load Capacity Curve (Blue):	153,686	kg
Existing Load Above Load Capacity Curve (Red):	57,797	kg
Estimated Load Reduction*:	27.3%	none

* Model predictions tend to overestimate loadings. Actual reductions required to meet the waste load allocations as defined by the load capacity curve may be less.

Figure 12c. Load-duration curve for zinc



Computed Load Indicators:	Value	Units
Total Storms Over 12-Year Period	249	none
Total Below Load Capacity Curve:	663,296	kg
Existing Condition (Red and Blue)	2,208,313	kg
Existing Load Below Load Capacity Curve (Blue):	643,105	kg
Existing Load Above Load Capacity Curve (Red):	1,565,209	kg
Estimated Load Reduction*:	70.9%	none

Figure 12d. Load-duration curve for cadmium

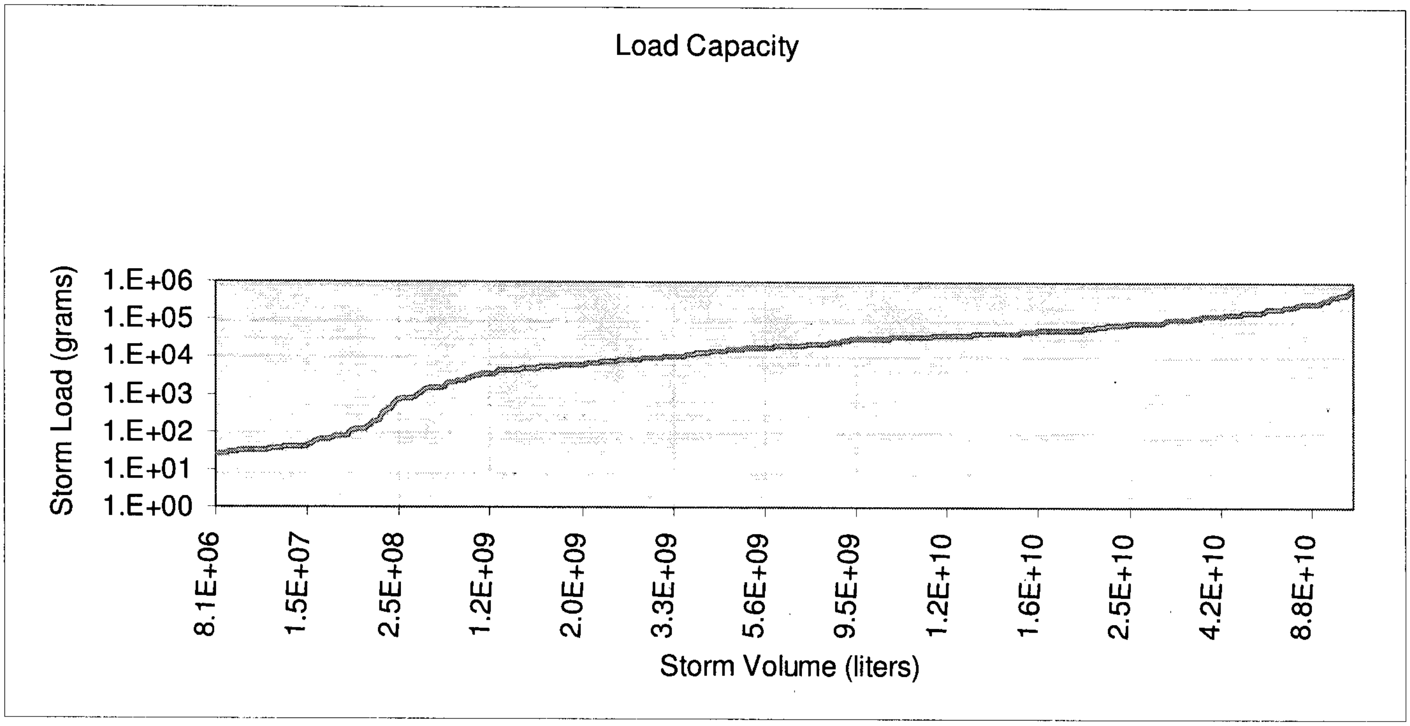


Figure 13. Regression analysis of storm flows verses rainfall for the Los Angeles River (below Wardlow)